Water Resources Management Plan

THEODORE ROOSEVELT

National Park • North Dakota

WATER

RESOURCES

MANAGEMENT

PLAN

THEODORE ROOSEVELT NATIONAL PARK

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North Dakota

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EXECUTIVE SUMMARY

Theodore Roosevelt National Park, consisting of three, physically separate units (North, Elkhorn, and South), is situated in the badlands of southwestern North Dakota, an area characterized by gently rolling uplands interrupted by buttes and ridges capped by resistant rock types. Connecting the three units is the main surface water resource in the park, the Little Missouri River. The northward-flowing Little Missouri River has incised about 200 to 500 feet into the upland surface with relief increasing northward. A series of advancing glaciers during the ice age redirected flows in a southeastwardly direction. This redirection created a steeper angle of flow for the Little Missouri River, resulting in faster waters and increased erosion. Adjustments continue as tributaries are cutting back into the uplands creating a northward-widening band of badlands about 6 to 18 miles wide.

Water is of critical concern for Theodore Roosevelt National Park because it is located in the semi-arid environment of the Northern Great Plains. Its scarce nature makes even small sources of water, such as seeps and springs or ephemeral streams, potentially critical to maintaining the riparian and aquatic habitat that support the local flora and fauna, and therefore are essential to maintaining the park’s biodiversity. However, there is a paucity of information on surface water features (springs and seeps), surface and ground water quantity and quality, and aquatic biology. Without better resource information, general trends of and specific impacts on water resources will remain undetected. This is especially critical considering the land use surrounding the park units.

Theodore Roosevelt National Park lies in the heart of the Williston Basin, a very successful oil and gas development area. Extensive oil and gas development such as various types of wells, storage tanks, pipelines, and transportation corridors surround and in some instances cross the park. Such developments, and their associated infrastructure, create a potential for oil and chemical contamination. Present and expected oil and gas development has the potential to seriously impair water quality, reduce surface and ground water quantity, and negatively affect biological resources in the park. With approximately 1,500 wells surrounding the park and another 630 wells forecast in the next 5-10 years, there is a high risk of surface and/or ground water contamination.

Within the Little Missouri River watershed, modern agricultural practices that use chemical herbicides, pesticides and fertilizers are also considered a potential threat to the park’s water resources. Livestock grazing and certain farming methods depend on Little Missouri River water and have the potential to impact water quality and quantity. Energy and agricultural activities, coupled with nonpoint source pollution associated with such activities (e.g. erosion, sedimentation, and siltation) and cumulative effects such as increases in trace metal concentrations pose a threat to surface and ground water resource integrity. Herbicides used in the park’s exotic plant control program could also have an impact on the water resources.

The primary purpose of this Water Resources Management Plan for Theodore Roosevelt National Park is to assist the park with water-related management decisions. In this regard, the report: 1) provides a detailed overview of existing water resource information; 2) identifies and discusses a number of water resource-related issues and management concerns; and 3) recommends a course of action for addressing high priority water resource-related issues at Theodore Roosevelt National Park. Recommendations for specific action can be found in the project statements in Appendix C. These can be incorporated into the park’s Resources Management Plan for future funding consideration.

A total of 13 water resource issues are identified and discussed. These issues have been prioritized into four high priority issues and eight medium priority issues. High priority issues include: 1) lack of baseline data on aquatic resources; 2) water rights; 3) oil and gas development; and, 4) effects of pesticides on park water resources. Medium priority issues include: 1) floodplain hazard identification; 2) City of Medora sewage treatment plant; 3) internal landfills; 4) cooperation and partnerships with other entities; 5) wild and scenic proposal; 6) possibility of sand and gravel extraction from the Little Missouri River; 7) underground storage tanks; and, 8) historical uranium mining.

Nine management actions or project statements were developed primarily for the high priority issues. This was considered prudent, given current funding and personnel constraints, i.e., the park would be only capable of addressing high priority issues over the lifespan of this plan, approximately 5 to 10 years. However, where applicable, recommendations are provided under medium priority issues. This would allow the park to respond to issues if their priorities shift in the future. Additionally, given the nature of a few project statements, both high and medium priority issues are addressed.

Introduction

INTRODUCTION

Whether supporting natural systems or providing for visitor use, water is a significant resource in units of the national park system. Consistent with its fundamental purpose, the National Park Service seeks to protect surface and ground waters as integral components of a park's aquatic and terrestrial ecosystems by carefully managing the consumptive use of water and striving to maintain the natural quality of surface and ground waters in accordance with all applicable federal, state, and local laws and regulations. In addition, water-based recreation such as fishing, as well as aquatic ecosystem health, are dependent upon the maintenance of adequate water quality.

Water is of critical concern for those parks located in the semi-arid environments of the Northern Great Plains. Its scarce nature makes even small sources of water, such as seeps and springs or ephemeral streams, potentially critical to maintaining the riparian and aquatic habitat that supports the local flora and fauna and therefore are essential to maintaining the parks' biodiversity.

The primary purpose of this Water Resources Management Plan for Theodore Roosevelt National Park is to assist park managers with water-related decisions. In this regard, the report provides a detailed overview of existing water resource information; identifies and discusses a number of water resource-related issues and management concerns; and, recommends a course of action for addressing high priority water resource-related issues at Theodore Roosevelt National Park. Project statements regarding critical water resources issues are included and can be incorporated into the park's Resources Management Plan (National Park Service 1998) for future funding consideration.

PARK LOCATION AND DESCRIPTION

Theodore Roosevelt National Park, consisting of three separate units (North, Elkhorn, and South) in southwestern North Dakota, is dedicated to the preservation and public enjoyment of important historic, scenic, and natural resources (Figure 1). The park is approximately 70,634 acres in size, with the North Unit containing 24,070 acres (Figure 2), the South Unit 46,128 acres (Figure 3), and the Elkhorn Unit 219 acres. Both the North and South units are completely enclosed with a 7-foot high fence; some of the more rugged areas still have barbed wire fence. The South and Elkhorn units are in Billings County, and the North Unit is in McKenzie County.

The North Dakota badlands comprise the primary scenic attraction. They straddle the Little Missouri River south of the City of Medora to the river's mouth east of the North Unit. The badlands within the park are only part of a larger region of dissected and banded hills and bluffs interspersed with grassy uplands. The central landscape feature unifying the Theodore Roosevelt National Park units is the free-flowing Little Missouri River (and its cottonwood-dominated riparian area), which flows through the North and South units and forms the eastern boundary of the Elkhorn Unit.

Theodore Roosevelt National Memorial Park was established in 1947. The park was established to honor Theodore Roosevelt, who made significant contributions to the conservation movement and the development of the West. The park's natural resources played a significant role in shaping the life of Theodore Roosevelt during the era of the open range cattle industry, which consequently influenced his role as a conservationist while he was President of the United States. In 1978, Congress established Theodore Roosevelt National Park and the Theodore Roosevelt Wilderness.

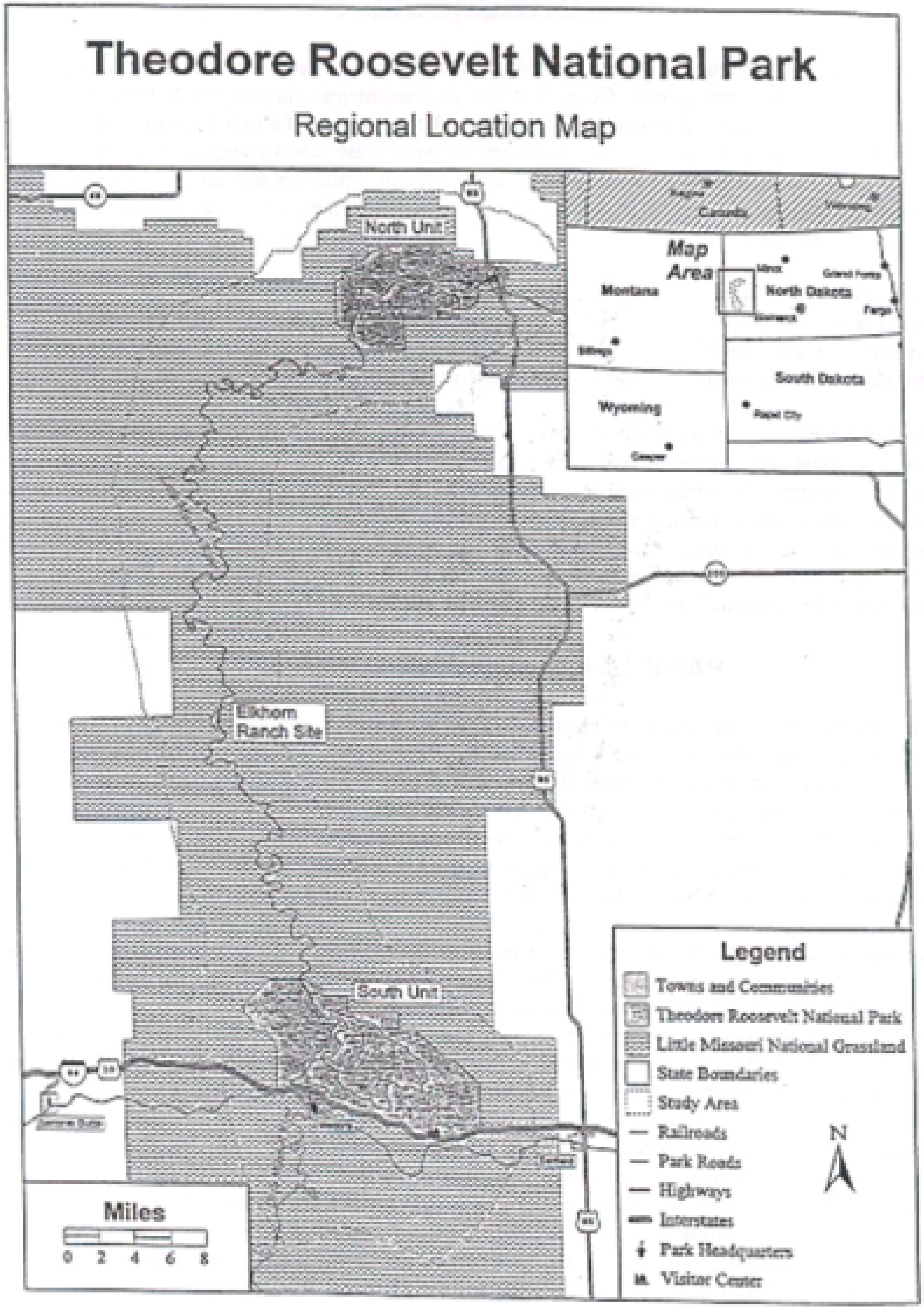

Figure 1. Regional location map for Theodore Roosevelt National Park (from National Park Service 1997).

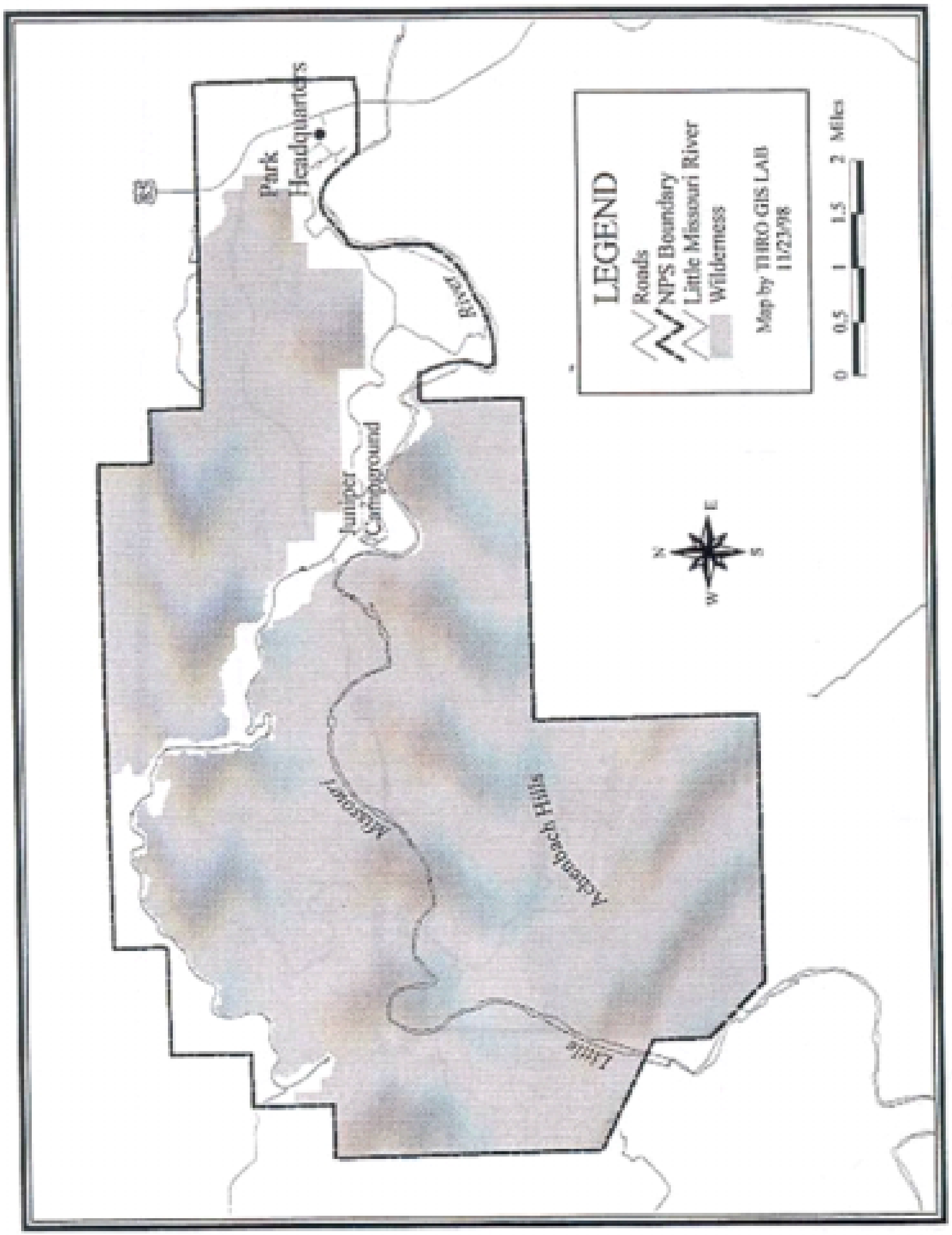

Figure 2. Map of North Unit, Theodore Roosevelt National Park.

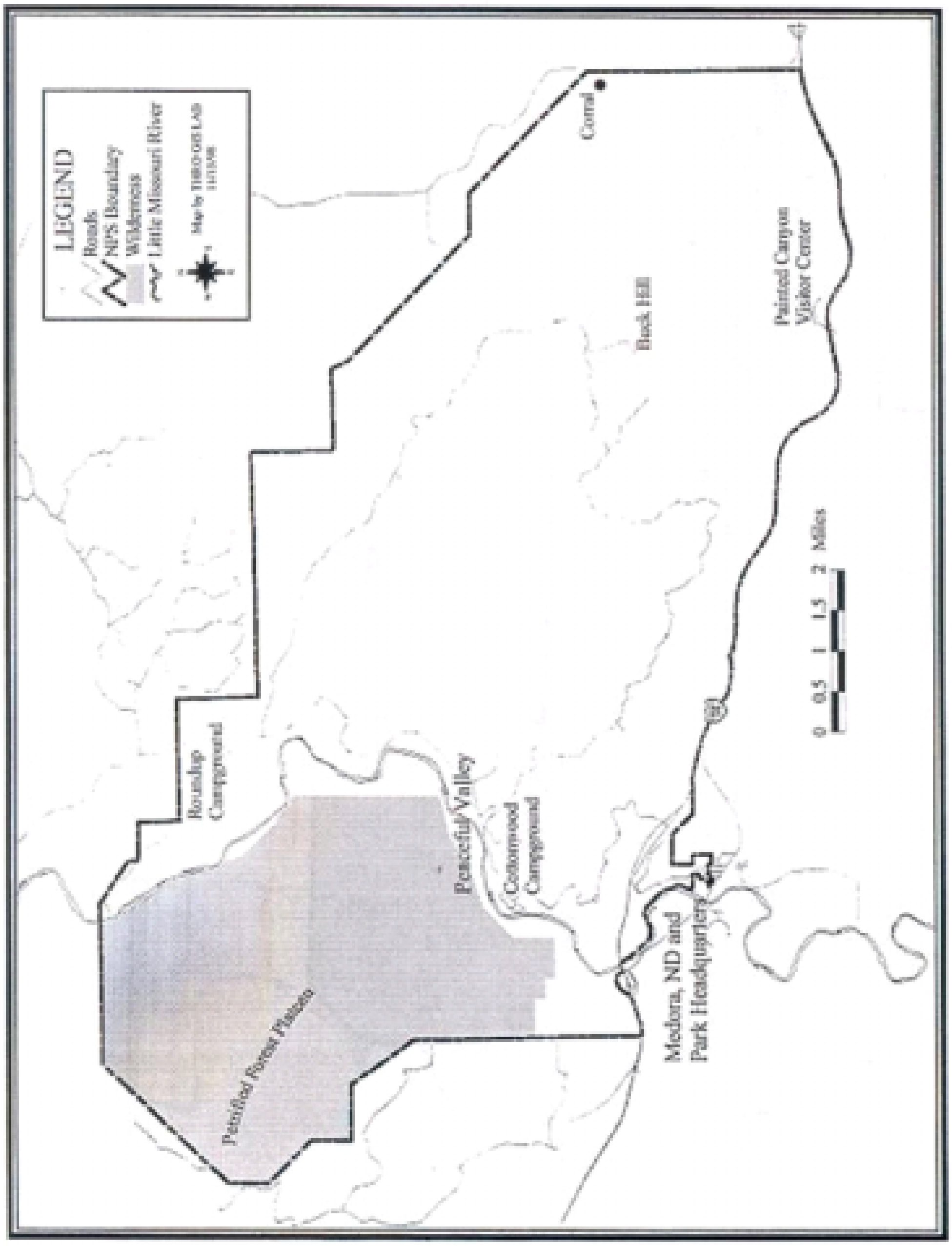

Figure 3. Map of South Unit, Theodore Roosevelt National Park.

While being managed primarily as a historical area during the early years of the park, management emphasis, in more recent years, has shifted toward the significance of the park as a natural area. A reflection of this shift is the deletion of the word “Memorial” from the park’s name in 1978, as well as the creation of the wilderness area, present in both the North and South units. Forty-two percent of the park has been designated as wilderness.

Nearly 800 species of vascular plants and 252 species of vertebrate wildlife are found in the park (National Park Service 1987). Reintroduced bison, bighorn sheep, and elk (Table 1), as well as native mule deer, white-tailed deer, pronghom, badger, beaver, coyote, porcupine, eagle, hawk, and the ubiquitous prairie dog are the most frequently observed wildlife. A herd of feral horses that roam the South Unit (Table 1) are popular with visitors, as well as an interpretive display in the North Unit featuring a herd of longhorn steers.

Table 1. Estimated numbers of reintroduced vertebrate species in Theodore Roosevelt National Park.

SPECIES	NORTH UNIT	SOUTH UNIT
Elk	0	200-250
Longhorn Steer	7	0
Bison	200	260
Feral Horses	0	92

Source: Theodore Roosevelt National Park Files

The park is divided into four management zones – natural, cultural, development, and special use (National Park Service 1987). The natural zone, the largest, encompasses approximately 68,032 acres. It is managed to perpetuate natural processes and the primitive character of the park. The cultural zone (245 acres) focuses on preservation, interpretation, and protection of historic and archeological resources. The development zone (1,685 acres) provides the necessary space for visitor and management facilities and utilities. The special use zone (485 acres) consists of land east of US 85 in the North Unit. This area is subject to scenic easements.

WATER RESOURCE MANAGEMENT OBJECTIVES

Water is an important resource for the functioning of natural systems and providing for visitor use in Theodore Roosevelt National Park. Its corresponding geomorphic extremes and habitat diversity allow the park to support diverse biological resources. Maintaining this diversity depends at least partially upon the careful maintenance of the park’s water resources and water-dependent environments, and minimizing stresses which can affect these resources from both inside and outside the park boundaries.

Specific management objectives pertaining to water resources and water-dependent environments within Theodore Roosevelt National Park include:

- Manage waters of the park and water-dependent environments in a manner designed to maintain the highest degree of biological diversity and ecosystem integrity;

- Preserve and restore natural springs and maintain developed wells for wildlife watering while ensuring protection of sources;

- Assure that park development and operations do not adversely affect the park's water resources and water-dependent environments;

- Acquire sufficient knowledge about water quality to effectively participate in state and local water management planning and seek the highest level of protection under state water quality standards appropriate for the park;

- Protect National Park Service (NPS) water rights and water related-resources by protesting applications for water rights that may adversely affect the park, and participating in general water rights adjudications that involve park lands;

- Acquire appropriate baseline information to adequately understand and manage water resources and meet NPS inventory and monitoring requirements;

- Minimize the risks of injury and property damage resulting from floods consistent with NPS Floodplain Management Guidelines, and more specifically, flood hazard identification, location of facilities out of flood hazard areas, and visitor and employee education, while still allowing natural hydrologic and geomorphic processes of floods to occur;

- Map wetland and riparian areas, and monitor and manage these resources in a manner that will maximize their biological integrity and enhance critical habitat for fish and wildlife;

- Promote public awareness and understanding of current and potential human impacts upon water resources;

- Develop and implement a cooperative management effort for the protection of rare and endangered fish species inside and out of the park;

- Detect and evaluate external influences that may impact NPS water resources and water related attributes; and,

- Ensure that permitted oil and gas operations outside the park are accomplished with minimal impact to both surface and ground water resources.

This Water Resources Management Plan provides a recommended course of management action for achieving these objectives.

LEGISLATIVE CONSTRAINTS

There are few legal or congressional constraints that impinge on management of the park exclusively. The Act of June 12, 1948 (62 Stat. 384) reserved to stockmen of the area surrounding the North and South units a perpetual right-of-way through the park along the Little Missouri River for the trailing of livestock to and from the railroad. In this same vein, the park is required to maintain and keep open the East River Road in the South Unit to the north boundary of the unit for use by ranchers living adjacent to the park.

The park is closed to mineral entry under the 1872 Mining Law and to mineral leasing of federally owned subsurface resources, including oil and gas. The legislation that provides the first basis for this determination is the Mineral Leasing Act of 1920. However, both the 1970 National Park Service Administration Act (PL 91-383, 84 Stat. 825) and the 1978 Redwood amendments to the NPS Administration Act (PL *95-250,* 92 Stat. 163) reaffirmed the park's closure to all forms of mineral entry and leasing.

Another constraint involves the approximately 745 acres of state and privately owned land within the park boundary. Congress included these lands to protect resources and allow for visitor use where appropriate, but the National Park Service has limited authority for their management as long as they are not federally owned. This constraint also applies to the 1342 acres of nonfederal or part nonfederal subsurface (mineral) rights within the park.

The park's separation into three distinct units makes it seemingly impossible to manage the area as an ecological unit. Maintaining natural area and wilderness characteristics is very difficult because of land uses on adjacent private, state, and federal lands. These uses include extensive oil and gas recovery operations and crop and livestock production. These activities have generated or exacerbated problems with air and water pollution, exotic plant infestation, and maintenance and protection of rare, threatened, or endangered plants and wildlife (National Park Service 1990).

Water-Related Legislation, Policies, and Executive Orders

Numerous federal and state laws, policies, and executive orders mandate specific regulatory considerations with regard to protection and management of water-related resources in and adjacent to the park. Additionally, policies and guidelines of the National Park Service broadly require management of natural resources of the national park system to maintain, rehabilitate, and perpetuate the inherent integrity of aquatic resources.

Federal

National Park Service Organic Act of 1916

Through this act, Congress established the National Park Service and mandated that it "shall promote and regulate the use of the federal areas known as national parks, monuments, and reservations by such means and measures as conform to the fundamental purpose of the said parks, monuments, and reservations, which purpose is to conserve the scenery and the natural and historic objects and the wildlife therein and to provide for the enjoyment of the same in such manner and by such means as will leave them unimpaired for the enjoyment of future generations." This act was reinforced by the

General Authorities Act of 1970 with legislation stating that all park lands are united by a common preservation purpose, regardless of title or designation. Hence, all water resources in the national park system are protected equally by federal law, and it is the fundamental duty of the National Park Service to protect those resources unless otherwise indicated by Congress.

Wild and Scenic Rivers Act of 1968

In accordance with this act, it is:

"...the policy of the United States that certain selected rivers of the Nation which, with their immediate environments, possess outstandingly remarkable scenic, recreational, geologic, fish and wildlife, historic, cultural, or other similar values, shall be preserved in free-flowing condition and that they and their immediate environments shall be protected for the benefit and enjoyment of present and future generations. The purpose of this act is to implement this policy by instituting a national wild and scenic rivers system, by designating the initial components of that system, and by prescribing the methods by which and standards according to which additional components may be added to the system from time to time."

Section 2 of this act states:

"The national wild and scenic rivers system shall comprise rivers (i) that are authorized for inclusion therein by act of Congress, or (ii) that are designated as wild, scenic or recreational rivers by or pursuant to an act of the legislature of the state or states through which they flow, that are to be permanently administered as wild, scenic or recreational rivers by an agency or political subdivision of the state or states concerned, that are found by the Secretary of the Interior upon application of the Governor of the state or the Governors of the states concerned, or a person or persons thereunto duly appointed by him or them, to meet the criteria established in this act and such criteria supplementary thereto as he may prescribe, and that are approved by him for inclusion in the system, including, upon application of the Governor of the state concerned."

Redwood National Park Act

In 1978, an act expanding Redwood National Park (i.e., Redwood National Park Act), further amended the general authorities of the National Park Service to mandate that all park system units be managed and protected "in light of the high public value and integrity of the national park system" and that no activities should be undertaken "in derogation of the values and purposes for which these various areas have been established," except where specifically authorized by law or as may have been or shall be directly and specifically provided for by Congress. Thus, by amending the general Authorities Act of 1970, the Redwood National Park Act reasserted system-wide the high standard of protection prescribed by Congress in the original Organic Act.

Wilderness Act of 1964

The Wilderness Act established the National Wilderness Preservation System, composed of federal lands designated as wilderness areas. A wilderness, in contrast with those areas where man and his own works dominate the landscape, is …an area where the earth and its community of life are untrammeled by man … an area of undeveloped federal land retaining its primeval character and influence … which is protected and managed so as to preserve its natural conditions which:

- appear to have been affected primarily by the forces of nature, with the imprint of man's work substantially unnoticeable;
- provide outstanding opportunities for solitude or a primitive and unconfined type of recreation; and,
- have at least 5,000 acres of land or are of sufficient size as to make practicable their preservation and use in an unimpaired condition.

Except as provided by law, there are to be no permanent roads within any wilderness area. Except as needed for administrative purposes, there are to be no temporary roads or use of motorized vehicles, or motorized equipment, no loading of aircraft, no other form of mechanical transport, and no structure or installation within any wilderness area.

In 1978 (Public Law *95-625)*, 29,920 acres (Figures 2 and 3) were designated wilderness within Theodore Roosevelt National Park. This wilderness designation, especially in the North Unit, could constrain water resource management activities, such as ease of access to monitoring stations and the need for structures for purposes of mitigation or reclamation.

Federal Water Pollution Control Act (Clean Water Act) of 1972

The Federal Water Pollution Control Act, more commonly known as the Clean Water Act, was first promulgated in 1972 and amended in 1977, 1987, and 1990. This law is designed to restore and maintain the chemical, physical, and biological integrity of the nation's water, including the waters of the national park system. Goals set by the act were swimmable and fishable waters by 1983 and no further discharge of pollutants into the nation's waterways by 1985. The two strategies for achieving these goals were a major grant program to assist in the construction of municipal sewage treatment facilities, and program of "effluent limitations" designed to limit the amount of pollutants that could be discharged. Effluent limitations are the basis for permits issued for all point source discharges, known as the National Pollutant Discharge Elimination System (NPDES). The U.S. Environmental Protection Agency (EPA) has set limits for pollutants that may be released based on available technology and cost of treatment for various industrial categories.

As part of the act, Congress recognized the primary role of the states in managing and regulating the nation's water quality within the general framework developed by Congress. Part of that framework, namely Section 313, requires that all federal agencies, including the National Park Service, comply with the requirements of state law for water quality management, regardless of other jurisdictional status or land-ownership. States implement the protection of water quality under the authority granted by the Clean Water Act through best management practices and through water quality standards. Standards are based on the designated uses of a water body or segment, the water quality criteria necessary to protect that use or uses, and an anti-degradation provision to protect the existing water quality.

Section 303 of the Clean Water Act requires the promulgation by states of water quality standards. Additionally, each state is required to review its water quality standards at least once every three years. This section also requires the listing of those waters where effluent limitations are not stringent enough to implement any water quality standard. Each state must establish, for each of the waters listed, total maximum daily loads for applicable pollutants.

Section 401 requires that any applicant for a federal license or permit to conduct an activity which will result in a discharge into waters of the U.S., shall provide the federal agency, from which a permit is sought, a certificate from the state water pollution control agency stating that any such discharge will comply with applicable water quality standards. Federal permits which require Water Quality Certification from the State of North Dakota include 404 permits from the U.S. Army Corps of Engineers for the discharge of dredged or filled material.

Section 402 of the act requires that a National Pollutant Discharge Elimination System (NPDES) permit be obtained for the discharge of pollutants from any point source into the waters of the U.S. Point source, waters of the U.S., and pollutants are all broadly defied under the act. However, in general, all discharges and storm water runoff from municipalities, major industrial and transportation activities, and certain construction activities must be permitted by the NPDES program. The State of North Dakota has been delegated NPDES permitting authority by the U.S. Environmental Protection Agency. The state, through the permitting process, establishes the effluent limitations and monitoring requirements for the types and quantities of pollutants that may be discharged into its waters. Under the antidegradation policy, the state must also insure that the approval of any NPDES permit will not eliminate or otherwise impair or degrade any designated uses of the receiving waters.

Section 404 of the Clean Water Act further requires that a permit be issued for discharge of dredged or fill materials in waters of the U.S. including wetlands. The U.S. Army Corps of Engineers administers the Section 404 permit program with oversight and veto powers held by the U.S. Environmental Protection Agency.

Endangered Species Act of 1973

The Endangered Species Act requires the National Park Service to identify and promote the conservation of all federally listed endangered, threatened or candidate species within park or preserve boundaries. While not required by legislation, it is the National Park Service's policy to also identify state and locally listed species of concern and support the preservation and restoration of those species and their habitats.

This act requires all entities using federal funding to consult with the Secretary of the Interior on activities that potentially impact endangered flora and fauna. It requires agencies to protect endangered and threatened species as well as designated critical habitats.

Floodplain Management Executive Order (No. 11988)

The objective of Executive Order (EO) 11988 (Floodplain Management) is "...to avoid to the extent possible the long- and short-term adverse impacts associated with the occupancy and modification of floodplains and to avoid direct and indirect support of floodplain development wherever there is a practicable alternative" (WRC 43 FR 6030). For non-repetitive actions, EO 11988 states that all proposed facilities must be located outside the limits of the 100-year floodplain. If there is “no practicable alternative” to construction within the floodplain, adverse impacts would be minimized during design of the project. National Park Service guidance pertaining to Executive Order 11988 can be found in Floodplain Management Guidelines (National Park Service 1993). It is National Park Service policy to recognize and manage for the preservation of floodplain values, minimize potentially hazardous conditions associated with flooding, and adhere to all federally mandated laws and regulations related to the management of activities in flood-prone areas. Particularly, it is the policy of the National Park Service to:

- restore and preserve natural floodplain values;

- avoid to the extent possible, the long- and short-term environmental impacts associated with the occupancy and modification of floodplain, and avoid direct and indirect support of floodplain development wherever there is a practicable alternative;

- minimize risk to life and property by design or modification of actions in floodplain, utilizing non-structural methods when possible, where it is not otherwise practical to place structures and human activities outside of the floodplain; and,

- require structures and facilities located in a floodplain to have a design consistent with the intent of the Standards and Criteria of the National Flood Insurance Program (44 CFR 60).

Protection of Wetlands Executive Order (No. 11990)

Executive Order 11990, entitled “Protection of Wetlands,” requires all federal agencies to “minimize the destruction, loss or degradation of wetlands, and preserve and enhance the natural and beneficial values of wetlands.” Unless no practical alternatives exist, federal agencies must avoid activities in wetlands which have the potential for adversely affecting the integrity of the ecosystem. National Park Service guidance for compliance with Executive Order 11990 can be found in the recently approved (October 1998) Director’s Order #77-1 and Procedural Manual #77-1, “Wetlands Protection”. Particularly, it is the policy of the National Park Service to:

- avoid to the extent possible the long- and short-term adverse impacts associated with the destruction or modification of wetlands;

- preserve and enhance the natural and beneficial values of wetlands;

- avoid direct or indirect support of new construction in wetlands wherever there is a practicable alternative;

- adopt a goal of “no net loss of wetlands” and strive to achieve a longer-term goal of net gain of wetlands Servicewide;

- conduct or obtain parkwide wetland inventories to help assure proper planning with respect to management and protection of wetland resources;

- use "Classification of Wetlands and Deepwater Habitats of the United States" (Cowardin et al. 1979) as the standard for defining, classifying, and inventorying wetlands;

- employ a sequence of first, avoiding adverse wetland impacts to the extent practicable; second, minimizing impacts that could not be avoided; and, lastly compensating for remaining unavoidable adverse wetland impacts at a minimum 1:1 ratio via restoration of degraded wetlands;

- prepare a Statement of Findings to document compliance with Director's Order #77-1 when the preferred alternative addressed in an environmental assessment or environmental impact statement will result in adverse impacts on wetlands; and,

- restore natural wetland characteristics or functions that have been degraded or lost due to previous or ongoing human activities, to the extent appropriate and practicable.

National Environmental Policy Act of 1969

Congress passed the National Environmental Policy Act (NEPA) in 1969. Environmental compliance in the National Park Service encompasses the mandates of NEPA and all other federal environmental laws that require evaluation, documentation and disclosure, and public involvement, including the Endangered Species Act, Clean Water Act, Executive Orders on Floodplains and Wetlands, and others.

All natural resource management and scientific activities are subject to environmental analysis under NEPA. Parks are encouraged to participate as cooperating agencies (40 CFR 1501.6) in the environmental compliance process to the fullest extent possible when National Park Service resources may be affected, and as set forth in Council on Environmental Quality (CEQ) regulations. Participation by the National Park Service in the environmental compliance processes of other agencies and jurisdictions is an important managerial tool. It can provide the National Park Service with information that will allow the Service to respond to possible external threats to a park well before they occur.

Section 102 of NEPA sets forth a procedural means for compliance. The CEQ (40 CFR 1500-1508) regulations further defme the requirements for compliance with NEPA.

Fish and Wildlife Coordination Act of 1965

This act requires federal agencies to consult with the U.S. Fish and Wildlife Service, or National Marine Fisheries Service, and with parallel state agencies, whenever water resource development plans result in alteration of a body of water. The Secretary of the Interior is authorized to assist and cooperate with federal agencies to "provide that wildlife conservation shall receive equal consideration and be coordinated with other features of water-resource development programs."

Energy Policy Act (EPA) of 1992

One major provision of EPA (1992) was a broadening of the existing ban on development of hydroelectric projects within national parks. New language bans new hydroelectric development within any unit of the national park system, including recreational areas, historical sites, and other units of the National Park Service. Previously, the ban affected only national parks and not other National Park Service units.

Safe Drinking Water Act of 1986

This act directs the U.S. Environmental Protection Agency to publish and enforce regulations on maximum allowable contaminant levels in drinking water. The act requires the Environmental Protection Agency to issue regulations establishing national primary drinking water standards. Primary enforcement responsibilities lie with the states. The act also protects underground sources of drinking water, with primary enforcement responsibilities again resting with the states. Federal agencies having jurisdiction over public water systems must comply with all requirements to the same extent as any non-governmental entity.

The 1996 amendments to the Safe Drinking Water Act initiated a new era in cost-effective protection of drinking water quality, state flexibility, and citizen involvement. Source water assessment and protection programs provided under these amendments offer tools and opportunities to build a prevention barrier to drinking water contamination. Source water protection means preventing contamination and reducing the need for treatment of drinking water supplies. Source water protection also means taking positive steps to manage potential sources of contaminants and contingency planning for the future by determining alternative sources of drinking water.

Sales of Park Water Under Public Law 91-383 (August 18, 1970)

Request for the National Park Service to provide water from park springs to a community adjacent to Grand Canyon National Park resulted in the passing of Public Law 91-383 in 1970 and its amendment in 1976 (P.L. 94-458). This law provides for the National Park Service to enter into contracts to sell or lease water to nearby communities, while recognizing that water is necessary for the protection of scenic, natural, cultural and scientific resources. The law establishes several tests that must be met before park waters can be sold or leased. Among the tests are: (1) that no reasonable alternative source of water exists, (2) that the services supported by the water sale are for the direct or indirect benefit of the park or park visitors, (3) that it is demonstrated that the sale is not detrimental to the park, its resources and visitors, (4) that the sale is consistent with federal water rights, and *(5)* that any agreement is short-term and revocable at any time. Any agreement to sell or lease water must also be reviewed by the appropriate congressional committees.

National Park Service Management Policies and Guidelines

The National Park Service Management Policies provide broad policy guidance for the management of national park system units. Those guidelines most directly pertaining to actions affecting water resources include:

- Director's Order 2, Planning Process;
- Director's Order 12 (draft), National Environmental Policy Act compliance;
- *NPS-75*, Natural Resources Inventory and Monitoring;
- NPS-77, Natural Resource Management; and,
- Director's Order 83 (draft), Public Health Management.

State

The North Dakota State Water Commission, and its chief officer, the State Engineer, are in charge of regulation, administration, and allocation of the state's water. The authorities include water rights allocation, drainage control, dike and dam safety, and floodplain management (North Dakota Administrative Code, Titles 89-02, 89-03, 89-08, and 89-10). Generally speaking, a permit is required for all uses of water except in cases when both the amount of water to be impounded, diverted, or withdrawn is less than 12.5 acre-feet and the contemplated use is domestic livestock, or fish, wildlife, and other recreation uses. Although no permit is required for these uses, the State Engineer must be notified of the location and acre-feet capacity stored or utilized once the facilities are constructed. The State Engineer administers the procedure for obtaining a conditional use permit. A conditional water permit reserves a specified volume of water for a specified use, subject to conditions that are a part of the permit. The conditions protect prior appropriators and the public interest.

The North Dakota State Water Commission does not specifically designate fish and wildlife as the most beneficial use relative to other resources in land and water management decisions. Additionally, fish, wildlife, and their habitats are only considered a factor in deciding beneficial use by the State Engineer, rather than the deciding factor in determining beneficial use. North Dakota Century Code (NDCC 6 1-04-06) establishes the criteria for issuance of a permit with fish and wildlife as a factor in determining if a proposed appropriation is in the public interest. Concurrently, NDCC 61-04-06.1 notes that if there are competing applications from the same source, and the source is insufficient to supply all applicants, the State Engineer shall adhere to the following priority: 1) domestic use; 2) municipal use; 3) livestock use; 4) irrigation use; *5)* industrial use; and, 6) fish, wildlife, and other outdoor uses. Finally, the State Engineer has no authority to directly establish minimum instream flows through the appropriation process – a requirement for an instream flow, however, could be established judicially.

The North Dakota Department of Health is charged with the regulatory responsibilities that ensure the health of the state's waters. Much of this is mandated and carried out as prescribed through federal laws, such as the Clean Water Act. The U.S. Environmental Protection Agency has delegated its authority under the National Pollution Discharge Elimination System to the state; this system is called the North Dakota Pollution Discharge Elimination system. This system requires permits for sewage treatment facilities as well as stormwater permits. Three general permits cover stormwater discharges covering mining and extraction activities, industrial activities, and construction activities.

LAND USE

Private land ownership for McKenzie and Billings counties is about 67 percent and 50 percent, respectively (National Park Service 1990). The National Park Service occupies about 1.3 percent of the land area in McKenzie County and 6.3 percent in Billings County. The U.S. Forest Service occupies about 27 percent of the land area in McKenzie County and 39 percent of the land area in Billings County. These Forest Service lands comprise the Northern and Southern Little Missouri grasslands, which essentially surround all three park units. Average land use statistics for the Little Missouri River watershed in North Dakota indicate that approximately 40 percent is rangeland, 31 percent of the land is cropland, 23 percent is federal noncropland, two percent is pastureland, and one percent is woodland (Crosby and Klausing 1984).

Grazing

Approximately 42 percent of the land in the Little Missouri River watershed is pasture or rangeland. Of the total 180 million acres of rangeland in the Northern Plains region, 26 percent is associated with soils of high wind erosion potential, and over 40 percent occurs in association with fragile soils. One hundred fifty-seven million acres of rangeland habitat are privately owned (Northern Prairie Wildlife Research Center 1998). The rangeland helps support about 23 million head of cattle in the Northern Plains, or 24 percent of the U.S. cattle population, and three million head of sheep, about 32 percent of the U.S. sheep population. Many wildlife species also depend on rangeland habitat.

Range condition data show that 71 million acres of rangeland in the Northern Plains are in poor or fair condition, primarily as a result of overgrazing (Northern Prairie Wildlife Research Center 1998). This in4icates a loss of higher successional plants, which can result in lost wildlife habitat, increased water runoff with increased soil erosion, increased soil loss from wind erosion, lost species diversity, and decreased productivity.

Park staff have cited concerns with problems related to overgrazing in areas outside park boundaries. Internally there are impacts from bison, elk, and horse grazing around seeps and springs. The physical effects of large numbers of bison using one seep or spring for their source of water at a particular time can have dramatic impacts on water resources and related vegetation in a relatively short period of time.

Mining

Historically, mining has been a viable economic activity in the region. This activity continues today (see Figure 4 in pocket) and affects water quality in and around the park. Mining activities in this drainage basin have been and remain coal, sand and gravel, stone, and uranium, though uranium mining is not economically viable at this time and has ceased.

The potential exists for large-scale recovery and processing of lignite in western North Dakota. Lignite is a relatively low grade form of coal, and it appears that mineral deposits are located near the North and South units of the park. When it is mined, lignite-fueled power plants are generally built close to the fuel source.

Oil and Gas Resources

Theodore Roosevelt National Park lies in the heart of the Williston Basin, a very successful oil and gas development area. Primarily due to this oil and gas development, the character of the area surrounding the park has changed greatly in the last two decades. Numerous oil fields surround all units of the park and contain active, shut-in, plugged, and saltwater injection wells; petroleum, gas, and saltwater pipelines; active and buried reserve pits; and, storage tanks. Pipelines cross the Little Missouri River, and wells and pipelines are located in river and stream floodplains upstream from the park. The potential exists for oil and/or chemical spills or well blow-outs that could cause both surface and ground water contamination in the immediate area as well as stream-carried pollution that could enter the park.

Historically, exploration in western North Dakota was targeted at oil production, which resulted in some associated gas discoveries. As early as 1909, a total of 25 gas wells had been drilled (U.S. Forest Service and Bureau of Land Management 1995). The first recorded oil well in the area was in 1920. This well was plugged as a dry hole, but was finished at a depth some 6,000 feet above potential oil production. Commercial gas wells were drilled and in production in the 1930s and l940s. The discovery well for the Williston Basin was the Iverson Well in Williams County, initially drilled in 1950; it was plugged back and completed in several different producing formations over a period of about 10 years.

A 1992 report by the North Dakota Geological Survey on oil and gas development potential of the Little Missouri National Grasslands contains a historic breakdown, by formation and year, of all drilling activity in the vicinity of the park between the first field discovery in 1951 and 1993 (cited in U.S. Forest Service and Bureau of Land Management 1995). During this time, 113 wells were drilled, an average of three wells per year. In the Southern Little Missouri and Cedar River National grasslands, 50 percent of these drilled wells were wildcats and 50 percent were development wells. Of the wildcat wells, one percent produced oil. Of the development wells, 30 percent were successful producers. Existing producing wells and non-producing wells are displayed in Figure 4 (in pocket).

There are hundreds of oil and gas wells within 6 or 7 miles of the boundaries of the three park units. These wells are predominately on areas of the Little Missouri National Grasslands and on private land (National Park Service 1990). Oil and gas wells and associated equipment are situated quite close to park boundaries -- 100 yards or less at some locations. The greatest concentrations and closest wells are situated to the north and northwest and to the south of the South Unit, and within the area adjacent to the Elkhorn Unit (Figure 4 in pocket). Oil and gas are being produced all around the North Unit, but wells are not as close nor in the same concentration that is evident around the South Unit.

In general, when a developed well is economically feasible, the resources needed to continue production will be committed to that use for 30 to 50 years (U.S. Forest Service and Bureau of Land Management 1995). Over the years, many existing and some newly drilled oil wells will no longer be profitable to operate. These wells will be plugged and the sites abandoned and reclaimed.

Potential oil and gas development in western North Dakota may be classified as quite high relative to other areas containing these same resources. The potential for additional development of oil and gas resources is rated as high in some areas near the park, especially in the Knutson and Government Creek watersheds in the South Unit (U.S. Forest Service and Bureau of Land Management 1995; Figure ~ in pocket).

Park Visitation

Over the last 10 years, annual visitation in Theodore Roosevelt has remained relatively steady at between 400,000 and 500,000 people per year (Figure *5).* There is a significant reduction in the number of annual visits after 1983 due to a change in the method that the park used to calculate this statistic -- a different multiplier (lower) and the use of a vehicle counter instead of estimating number of vehicles (Kaye 1997).

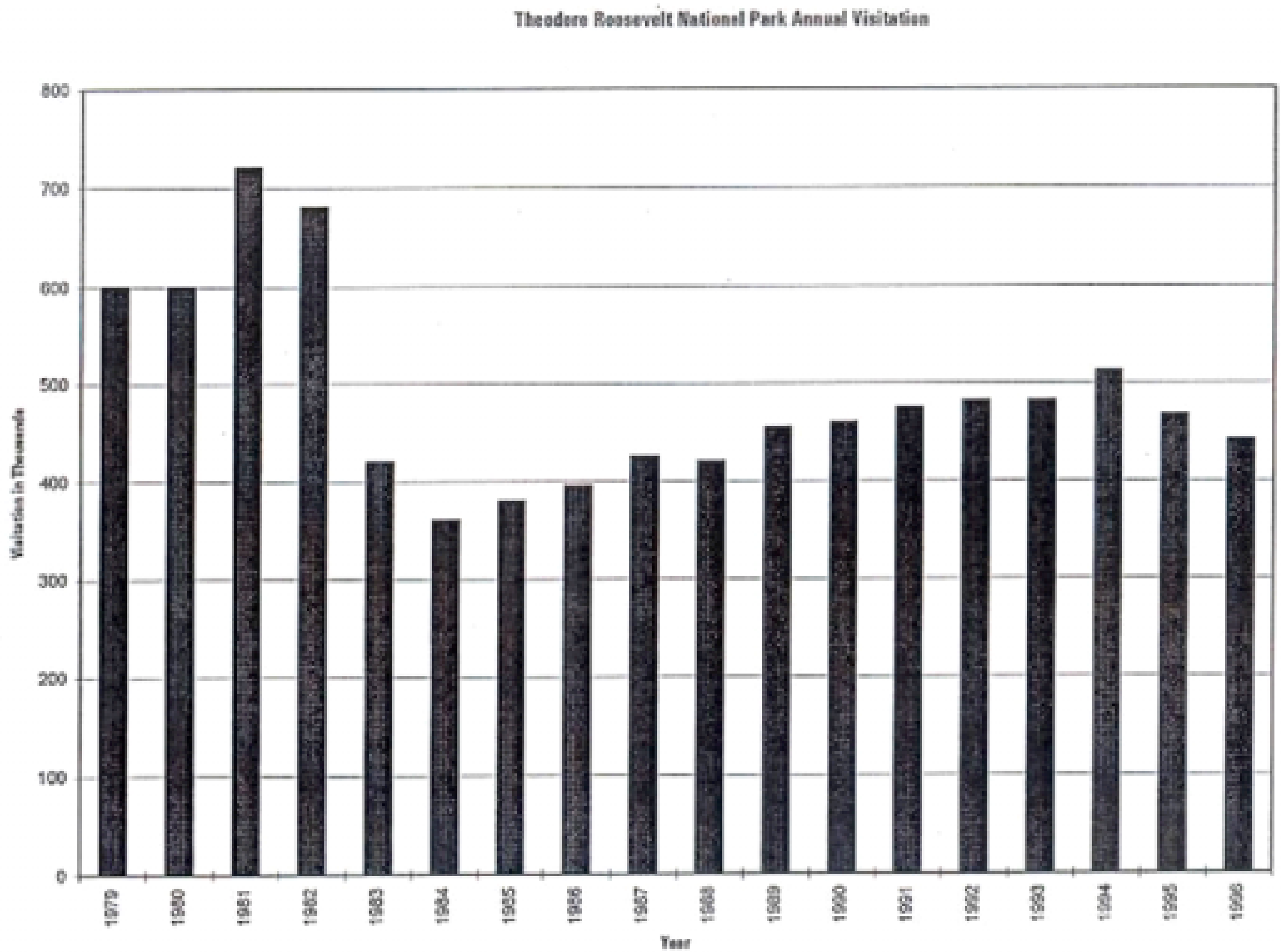

Figure 5. Annual visitation for Theodore Roosevelt National Park. Statistics provided by Theodore Roosevelt National Park.

Existing Resource Conditions

EXISTING RESOURCE CONDITIONS

CLIMATE

The climate of western North Dakota is typically semi-arid and continental, and characterized by long, cold winters and short, warm summers (Hansen et al. 1980). Temperatures range from *-35°* F to 100° F, with monthly averages ranging from 12° F in January to 71° F in July. The annual mean is 42.3° F. Average annual precipitation is approximately 15 inches; however, precipitation is erratic from year to year. For example, studies of drought frequency indicate that 11 to 12 inches of total precipitation occurred between 1988 and 1990 (U.S. Forest Service and Bureau of Land Management 1995). Drought conditions occur in southwestern North Dakota with an expectancy rate of 40 percent; usually they are of high intensity but short duration. Fifty percent of the precipitation occurs from May through July, with June the wettest month. Much of the summer rainfall comes as short, intensive, localized thunderstorms. These conditions can change normally dry streambeds into raging torrents within minutes. Snowfall averages approximately 30 inches per year, but steady winds usually prevent deep uniform accumulations.

GEOLOGY, TOPOGRAPHY AND SOILS

Physiographically, the park is located in westernmost North Dakota in the unglaciated Missouri Plateau Section of the Great Plains Province (Fenneman 1931). This section is characterized by gently rolling uplands interrupted by buttes and ridges capped by resistant rock types. However, the northward-flowing Little Missouri River has incised about 200 to 500 feet into the upland surface with relief increasing northward. A series of advancing glaciers during the ice age (12,000 BP) redirected flows in a southeastwardly direction (U.S. Forest Service and Bureau of Land Management 1995). This redirection created a steeper angle of flow for the Little Missouri River, resulting in faster waters and increased erosion. Adjustments continue as tributaries are cutting back into the uplands creating a northward-widening band of badlands about 6 to 18 miles wide.

Past oil exploration provides the basis for interpretation of the early geologic history of southwestern North Dakota (Carlson 1983; 1985). Sedimentation began *515* million years ago on a Precambrian surface of low relief. Each of the subsequent geologic periods are represented and alternate between marine deposition and emergence with erosion of part of the sedimentary section. Sedimentary sequences recognized are Sauk, Tippecanoe, Kaskaskia, Absaroka, Zuni, and Tejas (Figure 6). The sedimentary section is further subdivided into units of similar lithology and origin, which are defined as formations or groups. The stratigraphic column provides the group names as well as the general lithology and thickness (Figure 6).

Almost all the rock outcroppings in the badlands are of the Paleocene Tongue River and Sentinel Butte members of the Fort Union Group (U.S. Forest Service and Bureau of Land Management 1995; Figure 6). These formations are 60 million years old and are composed of layers of clay, silt and sand, interbedded with more weather resistant rocks such as shale, siltstone, sandstone, scoria, and lignite seams. The softer rocks erode very rapidly, while the more resistant rocks form the caps of buttes and cliffs. The badlands are often sculptured by a process of rapid mass gravity movements, such as slumps and earthflows, followed by creep, the very slow movement of loose particles downslope by gravity. Talus slopes and steep rocky slopes are the result of creep movements.

ERA	SYSTEM	SEQUENCE	FORMATION OR GROUP		THICKNESS (feet)	DOMINANT LITHOLOGY
CENOZOIC	QUATERNARY	TEJAS		ALLUVIUM	0- 40	Silt, Sand and Gravel
	TERTIARY			WHITE RIVER	0- 400	Conglomerate, Sand, Silt and Clay
		ZUNI	FORT UNION GROUP	GOLDEN VALLEY	0- 30	Silt, Clay and Sand
				SENTINEL BUTTE	0- 520	Silt, Clay, Sand and Lignite
				TONGUE RIVER	0- 370	Silt, Clay, Sand and Lignite
				SLOPE	0	Silt, Clay, Sand and Lignite
				CANNONBALL	0- 300	Mudstone and Sandstone
				LUDLOW	0	Silt, Clay, Sand and Lignite
MESOZOIC	CRETACEOUS		MONTANA GROUP	HELL CREEK	0- 450	Clay, Sandstone and Shale
				FOX HILLS	0- 320	Sandstone and Shale
				PIERRE	2,000-2,300	Shale
			COLORADO GROUP	NIOBRARA	170- 300	Shale, Calcareous
				CARLILE	350- 500	Shale
				GREENHORN	200- 350	Shale, Calcareous
				BELLE FOURCHE	240- 320	Shale
			DAKOTA GROUP	MOWRY	115- 200	Shale
				NEWCASTLE	0- 110	Sandstone
				SKULL CREEK	190- 325	Shale
				INYAN KARA	330- 430	Sandstone and Shale
	JURASSIC			SWIFT	400- 500	Mudstone
				RIERDON	50- 120	Shale and Sandstone
				PIPER	280- 370	Limestone, Shale and Anhydrite
	TRIASSIC					
PALEOZOIC	PERMIAN	ABSAROKA		SPEARFISH	400- 550	Siltstone and Salt
				MINNEKAHTA	35- 50	Limestone
				OPECHE	95- 330	Shale and Siltstone
	PENNSYLVANIAN		MINNELUSA GROUP	BROOM CREEK	110- 180	Sandstone and Dolomite
				AMSDEN	210- 400	Dolomite, Sandstone and Shale
				TYLER		Mudstone and Sandstone
	MISSISSIPPIAN	KASKASKIA		BIG SNOWY	200- 500	Shale, Sandstone and Limestone
				MADISON	1,350-2,300	Limestone, Anhydrite
	DEVONIAN			BAKKEN	0- 85	Shale and Siltstone
				THREE FORKS	0- 245	Shale, Siltstone and Dolomite
				BIRDBEAR	0- 90	Dolomite
				DUPEROW	180- 340	Interbedded Dolomite and Limestone
				SOURIS RIVER	50- 270	Interbedded Dolomite and Limestone
				DAWSON BAY	0- 80	Dolomite and Limestone
				PRAIRIE	0- 80	Limestone and Anhydrite
				WINNIPEGOSIS	0- 250	Limestone and Dolomite
	SILURIAN	TIPPECANOE		INTERLAKE	250- 920	Dolomite
				STONEWALL	75- 115	Dolomite
	ORDOVICIAN			STONY MOUNTAIN	110- 155	Argillaceous Limestone
				RED RIVER	510- 660	Limestone and Dolomite
			WINNIPEG GROUP	ROUGHLOCK	35- 50	Calcareous Shale and Siltstone
				ICEBOX	65- 95	Shale
				BLACK ISLAND	25- 115	Sandstone
	CAMBRIAN	SAUK		DEADWOOD	450- 950	Limestone, Shale and Sandstone
	PRECAMBRIAN ROCKS					

Figure 6. Stratigraphic column for Billings, Golden Valley, and Slope counties (after Carlson 1983).

Geologically, southwestern North Dakota is part of the Williston Basin, a large basin, 17,000 feet thick, that has persisted on the crotonic foreland from Precambrian time to the present (Figure 7). It is one of the largest and most productive basins for oil and gas resources in the continental United States (U.S. Forest Service and Bureau of Land Management *1995).* All System ages (epochs) are represented in the sediments preserved in the basin. However, similar to southwestern North Dakota geology, deposition was not continuous; numerous erosional nonconformities and stratigraphic changes, caused by tilting, sea level changes, and alternating marine and nonmarine deposition, are evident.

Marine hydrocarbon source beds have been developed in the Ordovician, Devonian, Mississippian, Pennsylvanian, and Cretaceous (U.S. Forest Service and Bureau of Land Management 1995). The Tertiary System is predominately non-marine, but contains hydrocarbon as lignite. Oil and gas reservoir rocks are present in all stratigraphic age groups from the Cambrian Deadwood Formation up through the Triassic Spearfish Formation, except the Permian, as evidenced by oil and/or gas production. Major oil-producing formations include most Mississippian formations, the Tyler of Pennsylvanian age, Devonian, Silurian, Ordovician, Cambro-Ordovician, and even some Precambrian rocks (Figure 6). The most important producing formations have been those of the Mississippian Madison Group, the Deadwood, Red River, Interlake, Duperow, Nisku, Bakken, and Tyler formations (U.S. Forest Service and Bureau of Land Management 1995).

There are numerous intervals that are not now producing, which appear to have reservoir properties if encountered in trapped conditions. These include, but are not limited to, the Mirinekahta Formation of Permian age, several formations in the Dakota Group of lower Cretaceous age, the Greenhorn Formation in the Colorado Group of Cretaceous age, and individual sands in Tertiary-age rocks (U.S. Forest Service and Bureau of Land Management 1995).

The park has two basic soil associations (Omodt et al. 1968; Crosby and Klausing 1984). Soils that are developed from Holocene and Pleistocene alluvium occur along the Little Missouri River and include Havre-Banks, Savage-Wade-Farland, Farland-Savage-Harlem, and Parshall Liher. These soils are grayish brown to very dark brown silty clay and silt loams to sand barns, and nearly level to rolling. Soils that are developed primarily from Tertiary and Cretaceous sandstone, siltstone, and shale occur elsewhere in the park and include Badlands-Bainville soils. These soils are dark grayish brown silt loam on crests and upper slopes of drainage divides, slopes of drainage divides, and steep barren slopes, and steep to rough topography.

VEGETATION

The vegetation of the park is adapted to the soil types and the semi-arid climate and varies according to slope, aspect, soil, and moisture availability. The National Park Service (1987) grouped the vegetation into six classes -- upland grasslands, dry breaks, wooded draws, sagebrush and grassland bottoms, floodplain forests, and a riparian class.

Figure 7. General boundaries of the Williston Basin (after U.S. Forest Service and Bureau of Land Management 1995).

More specifically, Hansen et al. (1980) delineated 10 habitat types within Theodore Roosevelt National Park. A needlegrass *(Stipa comata)/sedge (Carexfil~folia)* habitat type occurs on upland plateaus and gentle slopes that are relatively free from excessive erosion and deposition. The western wheatgrass *(Agropyron smithii)Isedge (C. fll~folia)* habitat type occurs on hillsides of nine to 20 percent slope. The little bluestem *(Andropogon scoparius)/sedge (C. fil~folia)* habitat type is restricted to apparently mesic sites. The habitat type of creeping juniper *(Juniperus horizontalis)!* little bluestem *(An. scoparius)* is found on slopes greater than 28 percent and restricted to mesic sites. A big sagebrush *(Artemisia tridentata)/western* wheatgrass *(Ag. smithii)* habitat type occurs on river terraces or contoured microbenches 30 to 300 feet above the valley floor of the Little Missouri River and its principle tributaries. The dwarf sagebrush *(Artemisia* cana)/western wheatgrass *(Agropyron smithii)* habitat type occurs on nearly flat or uniformly sloping floodplains or slightly elevated terraces along the Little Missouri and its tributaries. These sagebrush flats are prominent and occupy large areas. The habitat type of red ash *(Fraxinus pennsylvanica)/we* stem snowberry *(Symphoricarpos occidentalis)* is restricted to the floodplain of the Little Missouri and some of its major tributaries where soil moisture is greater than normal for the region. A red ash *(Fraxinus pennsylvanica)/choke* cherry *(Prunus virginiana)* habitat type is characteristic of upland draws or coulees, broad valleys or moderately steep north-facing slopes. The quaking aspen *(Populus tremuloides)/mountain* birch *(Betula occidentalis)* habitat type is characteristic of the upper parts of relatively steep northwest to east-facing slopes of draws and ravines. Rocky mountain juniper *(Juniperus scopulorum)/little-seed* ricegrass *(Oiyzopsis micrantha)* occupies cool mesic north-facing slopes of the rougher parts of the park.

The distribution and abundance of the natural vegetation have been changed by activities such as grazing, cultivation, and protection from fire. Leafy spurge *(Euphorbia esula),* Canada thistle *(Cirsium arvense),* yellow sweet-clover *(Melilotus officinalis),* brome grasses *(Bromus* spp.), and other exotic plants are widespread.

As a high priority within the Inventory and Monitoring Program of the National Park Service, a 1997 vegetation mapping project at Theodore Roosevelt National Park will provide comprehensive vegetation information in a geographic information system framework for the park. This project is scheduled for completion in early 1999.

Leafy Spurge

Leafy spurge is a deep rooted, perennial weed (Stevens 1963). This species reproduces by both vegetative buds and the production of large quantities of seeds. A native of Eurasia, leafy spurge was first reported in the U.S. in 1927 (Noble et al. 1979). It now occurs abundantly on the Northern Great Plains where it forms stands dense enough to displace native plants and restrict cattle grazing (Rees and Spencer 1991).

Leafy spurge is the most harmful exotic plant in Theodore Roosevelt National Park with the greatest potential for damage to native plant communities (Redente 1993). It causes severe impacts to the ecosystem due to its aggressive growth relative to that of native flora; ability to invade non-infested habitats; persistence once established; and, capability to alter ecological processes and visitor perceptions of the park.

Leafy spurge was first reported in Theodore Roosevelt National Park in the late 1960s. In 1970, an estimated 32 acres was infested. The infestation increased to 400 acres between 1975 and 1983, and was conservatively estimated as approximately 700 acres in 1986 (Anderson et al. 1994). Leafy spurge can be found throughout the park in all habitat types, although it prefers stream beds, drainages, and wooded draws. The heaviest concentrations are found west of the Little Missouri River in the South Unit where spread has been rapid (Figure 8).

An integrated pest management approach is being used to contain leafy spurge, i.e., the combined use of several control methods (National Park Service 1994). The use of herbicides is one of these control methods. Herbicides applied repeatedly have been shown to control leafy spurge topgrowth and gradually decrease its root system (Anderson et al. 1994). Herbicides considered for use in the park to control leafy spurge include combinations of 2,4-D, glyphosate, picloram, and fosamine ammonium. Since leafy spurge prefers floodplain areas, there is a distinct possibility of surface and ground water contamination.

SURFACE WATER

Little Missouri River

The major surface water resource in the park is the Little Missouri River whose headwaters are found in northeastern Wyoming. The Little Missouri River is 560 miles long and generally flows northeast, with an average gradient of 4.6 feet per mile, where it terminates upon entering the Sakakawea Reservoir. The river undergoes constant bed scour, a condition not expected given the relative low gradient. The bed scour is probably a result of the highly erodible bed material derived from the surrounding Badlands.

Theodore Roosevelt National Park is located midway within the watershed of the Little Missouri River. The river bisects the park’s designated wilderness, flowing through 9 miles of the South Unit and 14 miles of the North Unit. The river forms approximately one mile of the eastern boundary of the Elkhorn Unit. The Little Missouri River has a drainage area of about 4,750 square miles in North Dakota.

Benke (1990) analyzed the Nationwide Rivers Inventory, a database maintained by National Park Service, to determine free-flowing streams and rivers of high quality. His criteria for a quality stream was one that was essentially free-flowing for more than 320 miles, in a relatively undeveloped corridor, and possessing outstanding natural and cultural values. Stanford and Ward (1979) used *155*-mile uninterrupted stream lengths as one of their criteria. Rabeni (1997) combined elements of both studies to determine that only 14 rivers in the entire prairie region are free flowing and possess a moderately high degree of biological diversity. The Little Missouri River in North and South Dakota is one of these rivers.

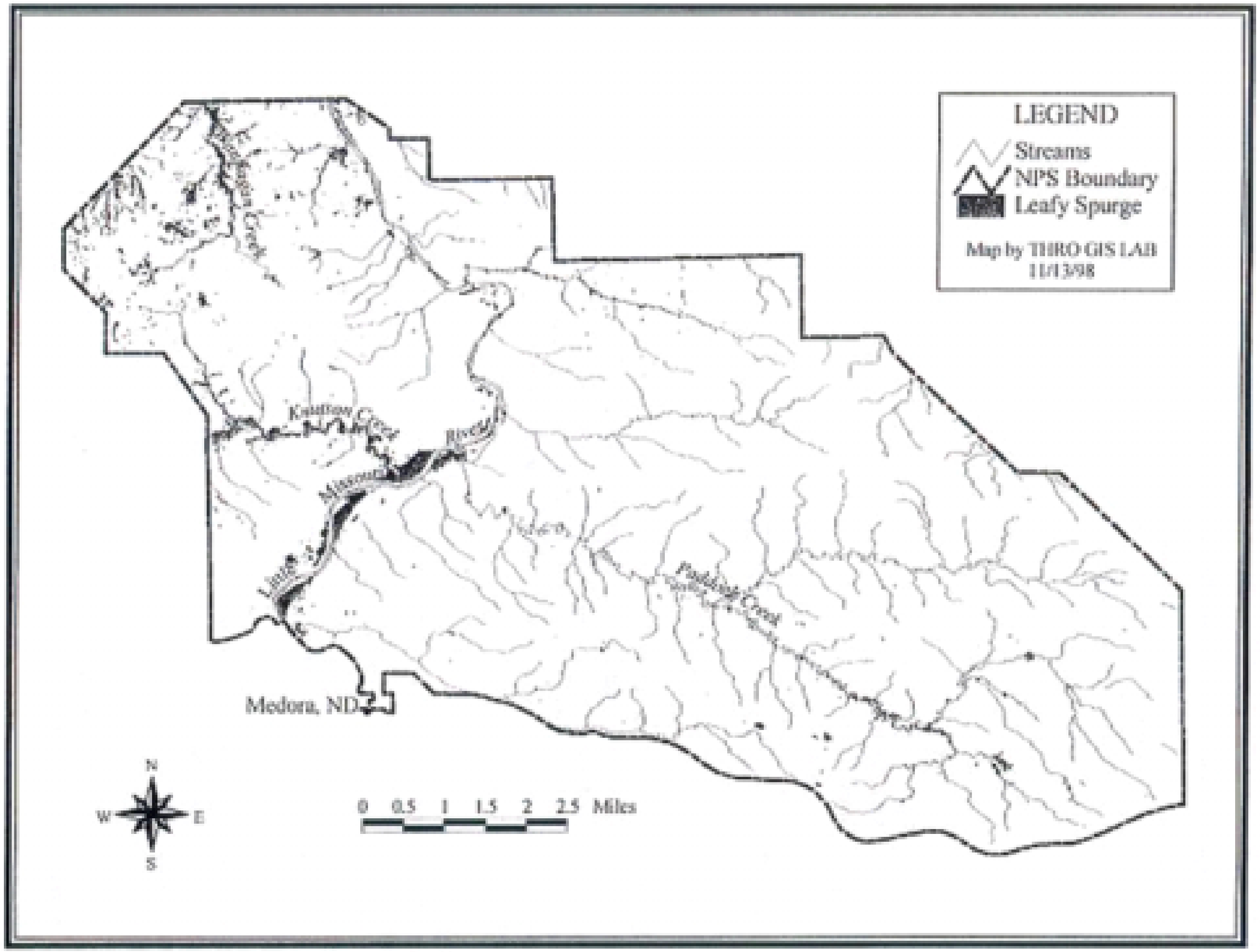

Figure 8. Map of leafy spurge infestations in the South Unit, Theodore Roosevelt National Park.

The State of North Dakota has designated the Little Missouri River as a State Scenic River. The North Dakota Parks and Recreation Department (1987) evaluated rivers throughout the state and gave the following “Resource Ratings” (1 being the highest out of 4) for this river.

Resource Ratings for the Little Missouri River

Feature	**Rating**
Geologic/Hydrologic Features	1
Botanical Resources	1
Zoological Resources	2
Unique Ecological Communities	1
Historic,Prehistoric Sites	1
Sport Fishing	1
Recreational Resources	1
Water Quality	1
Forest Resources	1
Breeding Waterfowl	4
White-tailed Deer	1

Source: North Dakota Parks and Recreation Department (1987).

Only the Missouri River received as high an overall evaluation. This study further noted:

The Little Missouri River is clearly a major resource of Theodore Roosevelt National Park and all National Park Service planning and management actions should protect the identified resource values associated with this river. Since the Little Missouri River also flows through other public and private lands, the National Park Service should actively develop “partnerships” with the appropriate public and private entities to achieve the desired protection and management of this critical resource.

The Little Missouri River is~ also eligible for National Wild and Scenic River designation. The process of determining whether this river will be designated as such is in its initial stages. Public comment on this designation was included in the scoping of the Revised Land and Resource Management Plans for Several National Grasslands and Forests on the Northern Great Plains (Federal Register: February 26, 1997, Vol 62, No 38, pp. 8680-8685). The comment period closed on July 31, 1997. The U.S. Forest Service and the National Park Service are cooperatively evaluating the river for designation (Ohlrogge 1997).

The U.S. Geological Survey has collected streamflow data at three, long-term gaging stations on the Little Missouri River in North Dakota. The Medora and Watford City gaging stations are located in the park, the Marmarth gaging station is located south of the park. The Medora station has been discontinued. No tributary streams within the park or adjacent to it have installed gages.

The volume of flow in the Little Missouri River system varies greatly from year to year (Figure 9) and season to season (Figure 10). The Little Missouri River is characterized by wide fluctuations of flow,

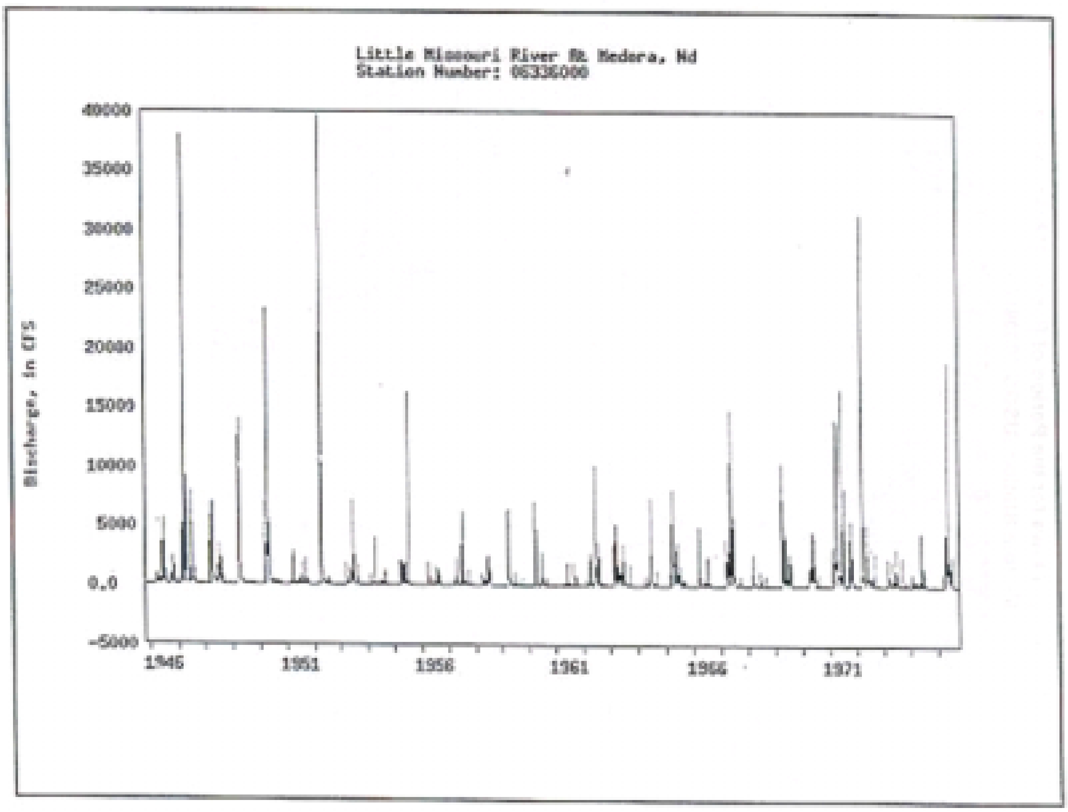

Figure 9. Historical daily values for streamflow for the Little Missouri River at Medora, North Dakota (after U.S. Geological Survey at http://www.usgs.gov).

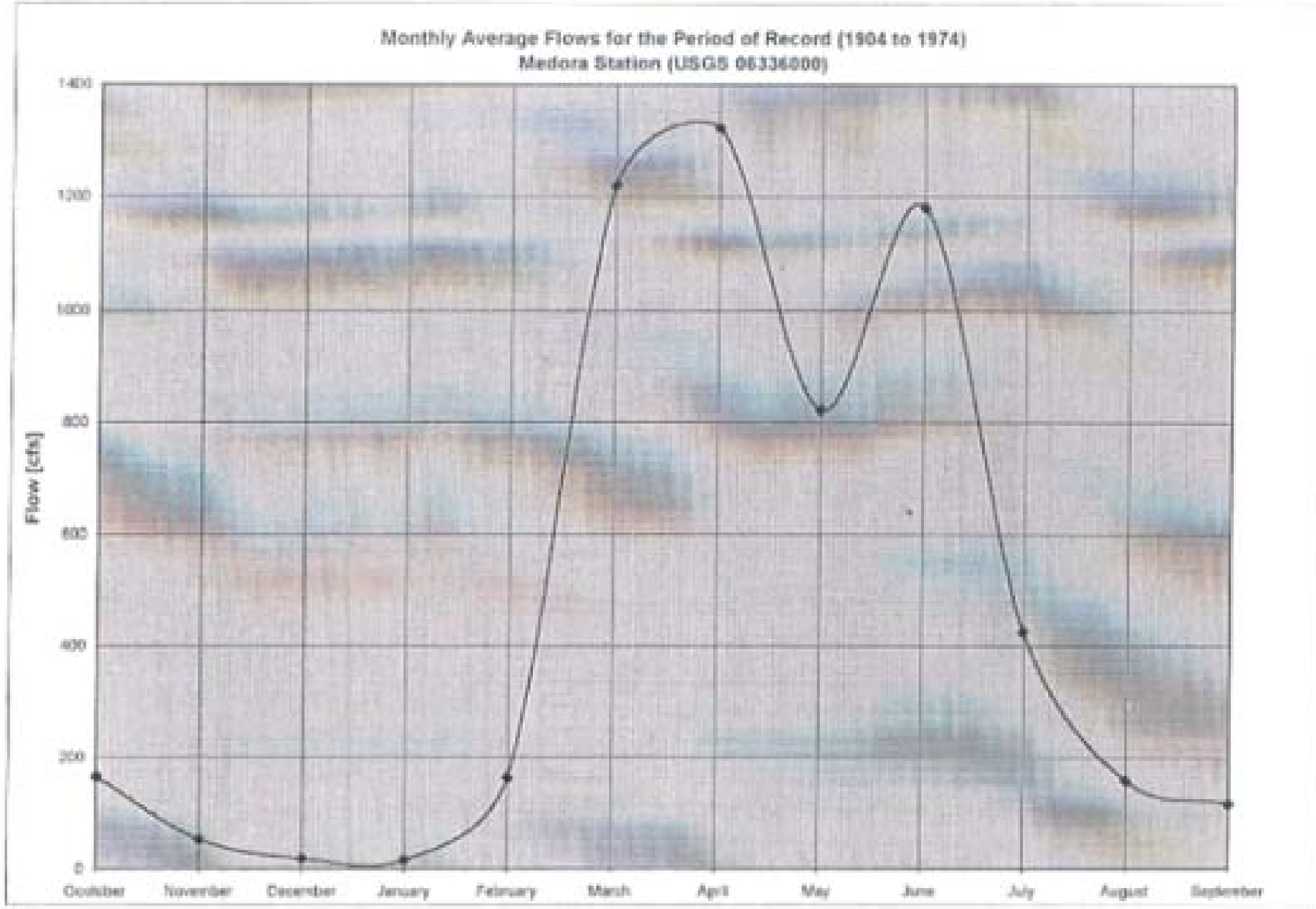

Figure 10. Monthly average flows for Little Missouri River at Medora, North Dakota (based on U.S. Geological Survey data at http://www.usgs.gov).

from as low as no discharge to as high as 65,000 cfs (cubic feet per second). The lowest flows typically occur in winter (December and January), whereas peak flows occur in March and April, probably the result of snowmelt runoff. A secondary peak in June probably coincides with the advent of summer thunderstorms. Complete cessation of flow occurs in dry seasons and leaves only disconnected pools in the stream bed.

The flow duration curve of discharges (a cumulative frequency distribution of daily flows) for the Medora gaging station is characteristic of a “flashy” river with low flows (discharges less than 1000 cfs) occurring approximately 90 percent of the time and high flows (discharges above 5000 cfs) occurring relatively infrequently (Figure 11). The data also suggest that the “base flow” (the ground water contribution to surface flow) of the Little Missouri, while critical to maintaining low flows in the river (Anna 1981), is a relatively minor contributor to the total discharge of the Little Missouri River.

Morphologically, the Little Missouri River within park boundaries represents the “C” stream type in the Rosgen classification (Rosgen 1996). This stream type is located in narrow to wide valleys constructed from alluvial deposition. The channels have a well-developed floodplain, are relatively sinuous with a channel slope of two percent or less, and a bedform morphology indicative of a riffle/pool configuration. The “C” stream type exhibits a sequencing of steeps (riffles) and flats (pools) where the riffle/pool sequence or spacing is on average approximately five to seven bankfull channel widths. “C” stream types characteristically have point bars, and channels of this stream type can be significantly altered and rapidly destabilized when the channel stability threshold is exceeded due to a combination of the effects of imposed changes in bank stability, watershed condition, or flow regime.

The majority of first, second, and third order tributary streams are ephemeral with the higher order streams being intermittent. Ephemeral streams are those that flow briefly only in direct response to precipitation in the immediate locality and whose channels are at all times above the water table. Intermittent or seasonal streams are those in contact with the ground water table and flow only at certain times of the year. as when the ground water table is high and/or when it receives water from springs or from some surface source such as melting snow. Knutson Creek (drainage 64 square miles), Paddock Creek (28 square miles), and Government Creek (just outside of boundary) are intermittent streams in the South Unit, and Squaw Creek *(26.5* square miles) is an intermittent stream of note in the North Unit.

Tributary systems within the park exhibit a channel morphology that ranges from Rosgen stream type “G4” to “G6” (Rosgen 1996). Due to their relatively young geologic age, these channels are still in the process of seeking dynamic equilibrium. Degradation or downcutting into streambed materials is prevalent. These channels are entrenched, gravel, sand or siltlclay dominated, and unstable with a high sediment supply from heavy bank erosion rates, a gully step pool morphology with moderate slopes, and a low width-to-depth ratio. They are located in narrow valleys, or deeply incised in alluvium or colluvium. These “sandy gully” stream types transport great amounts of sediment due to ease of particle detachment and fluvial entrainment. Bedload transport rates can easily exceed 50 percent of total load with active, consistent channel erosion more typical than not. These channel types are extremely sensitive to disturbance and have poor recovery potential once disturbed. When the balance has been disturbed by human-induced activities, it is exceedingly difficult to restore these actively-degrading streams.

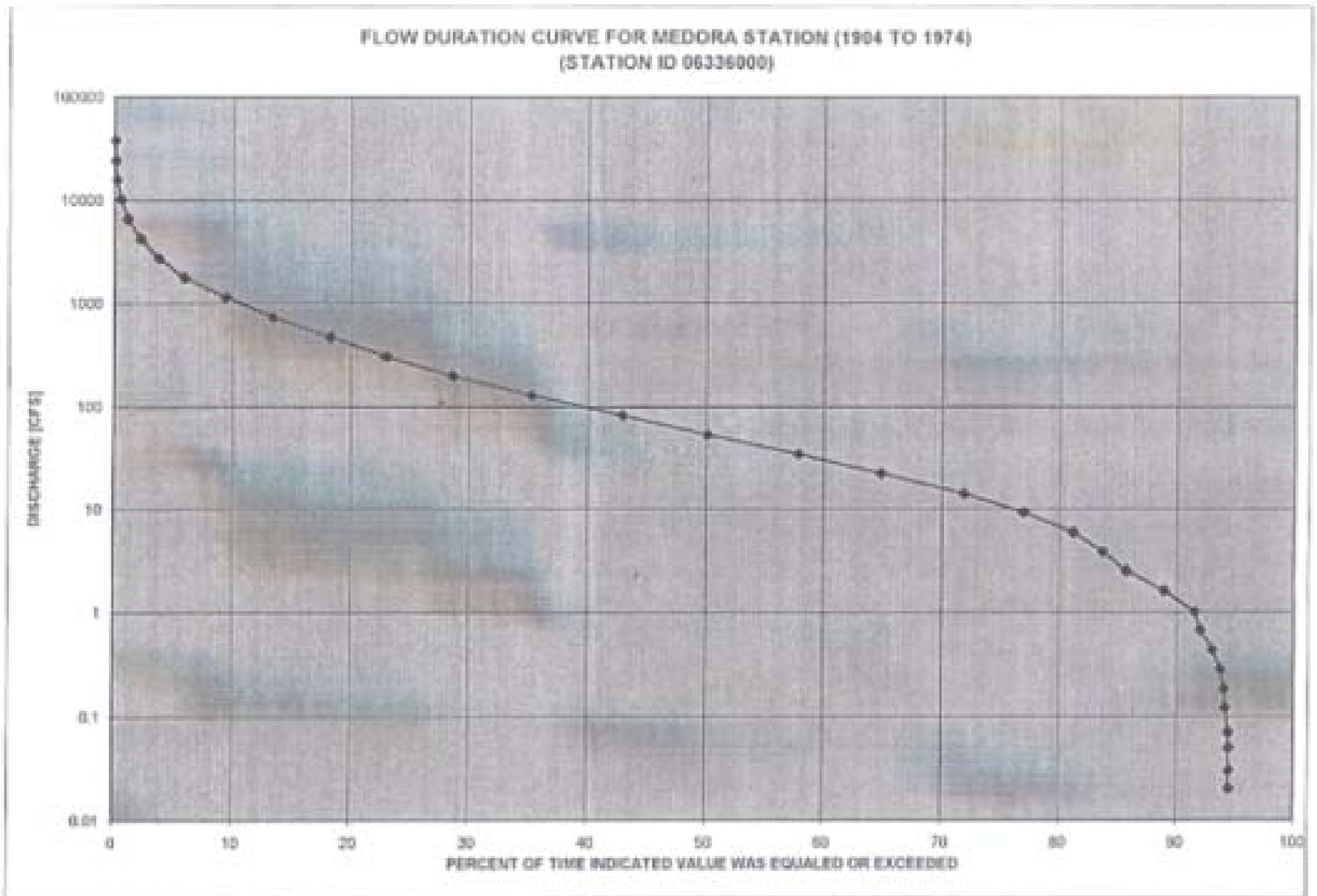

Figure 11. Flow duration curve for Little Missouri River at Medora, North Dakota (based on U.S. Geological Survey data at http://www.usgs.gov).

Floodplain and Riparian Areas

Floodplains, riparian areas, wetlands, springs and seeps occur at the interface between land and water. While collectively these areas represent only a very small proportion of the landscape in Theodore Roosevelt National Park, their hydrologic and ecologic importance is significant. Individually and collectively, these areas provide many critical functions including water supply, maintenance of water quality, flood attenuation, essential habitats for flora and fauna, and maintenance of the park's biodiversity. The importance of these areas and their natural functions is magnified by the fact that the park is semiarid, which makes all water-related areas especially valuable.

Discharges and water-surface elevations for 100- or 500-year floods or both were computed for selected reaches along the Little Missouri River for the North, South and Elkhom units as well as for Knutson, Paddock, and Squaw creeks (Emerson and Macek-Rowland 1986; Table 2). Based on this information the National Park Service mapped the floodplains (National Park Service 1987). Many structures and facilities in the park are in the 100-year floodplain of the Little Missouri River and the 100-year flash flood hazard area of two of its tributaries – Paddock and Squaw creeks (National Park Service 1987).

Table 2. Flood discharges and water surface elevations for Theodore Roosevelt National Park.

Reach	Recurrence Interval in years	Discharge (cubic feet/second)	Elevation Range (feet)
Little Missouri River South Unit	100 500	65,300 99,300	2247-2272 2251-2276
Little Missouri River ElkhornUnit	100 500	69,000 103,000	2129-2135 2133-2138
Little Missouri River NorthUnit	100 500	78,800 113,500	1947-1967 1951-1971
Knutson Creek	100	31,800	2260-2270
Paddock Creek	100	18,500	2253-2259
Squaw Creek	100	24,600	1975-1980

Source: Emerson and Macex-Rowland (1986).

According to the park's General Management Plan (National Park Service 1987), a large portion of the Town of Medora, including park headquarters, the Medora Visitor Center, Maltese Cross Cabin, and most of the park housing area, are within the 100-year floodplain, as are the Cottonwood Campground, the Peaceful Valley area, and all the historic remains in the Elkhom Unit. In addition, the Juniper Campground and picnic area (including all historic structures) and approximately one-half of the North Unit bison corral are in the 100-year floodplain.

The Peaceful Valley Ranch and picnic area are in the Paddock Creek 100-year flash flood area, and the Juniper Campground and picnic area is within the Squaw Creek 100-year flash flood area (National Park Service 1987). Flash floods could also be experienced in the Knutson Creek drainage, but no developments other than trails are located along this stream. Within these three flash flood areas are segments of several trails, short portions of which cross Squaw, Paddock, and Knutson creeks.

Flooding from the Little Missouri River and Squaw, Paddock and Knutson creeks causes a hazard to persons and property. The flood hazard of the Little Missouri River alone is very different from that of the three creeks. The Little Missouri River has a relatively large drainage basin, and the threat of flood may be known days in advance. The velocity of flood flows in the floodplain is considerably less than that in the main channel. In contrast, flooding from the three creeks will most likely be caused by intense, local thunderstorms, and the threat of a flood may be known only hours in advance. The flood water will flow at fast velocities, filling the floodplain of the creek (Emerson and MacekRowland 1986). Once the flood water of a creek reaches the floodplain of the Little Missouri River, the water will spread out, reducing the velocities and depths.

Park personnel have witnessed winter ice jam flooding on the Little Missouri River, especially in the South Unit near the Cottonwood Campground (Andrascik 1996). In contrast to open-water flooding, where high water levels directly result from excessive water discharge, ice jam flooding results from added resistance to flow and blockage of flow caused by accumulations of ice (White and Kay 1996). The formation of an ice jam on a river doubles the wetted perimeter of a wide channel. The added resistance to flow, along with the reduction in flow area caused by the ice, results in higher stages than a comparable open-water discharge would produce, despite discharge recurrence intervals of two years or less (Wuebben and Gagnon 1995). Ice jams within the park can cause severe local flooding, disrupt local water supplies, and damage recreational facilities and bridges.

Natural riparian zones are some of the most diverse, dynamic, and complex biophysical habitats in the terrestrial environment (Naiman et al. 1993). The riparian zone encompasses that stream channel between low and high watermarks and that portion of the terrestrial landscape from the high watermark toward the uplands where vegetation may be influenced by elevated water tables or flooding and by the ability of the soils to hold water (Naiman and Decamps 1997). The riparian zone may be small in the numerous headwater streams. In mid-sized streams, the riparian zone is larger, being represented by a distinct band of vegetation whose width is determined by long-term (>50 years) channel dynamics and the annual discharge regime. Riparian zones of large streams are characterized by well developed but physically complex floodplains, with long periods of seasonal flooding, lateral channel migration, oxbow lakes in old river channels and a diverse vegetative community (Malanson 1993). These attributes suggest that riparian zones are key systems for regulating aquatic-terrestrial linkages (Ward 1989) and that they may provide early indications of environmental change (Decamps 1993).

Physically, riparian zones control mass movements of materials and channel morphology (Naiman and Decamps 1997). Material supplied to streams comes from erosion of stream banks, a process influenced by root strength and resilience, as well as from the uplands. Stream banks largely devoid of riparian vegetation are often highly unstable and subject to mass wasting that can widen channels by several to tens of feet annually. Major bank erosion is 30 times more prevalent on nonvegetated banks exposed to currents as on vegetated banks (Beeson and Doyle 1995).

In addition, riparian zones provide woody debris. Woody debris piles dissipate energy, trap moving materials, and create habitat (Naiman and Decamps 1997). Depending upon size, position in the channel, and geometry, woody debris can resist and redirect water currents, causing a mosaic of erosional and depositional patches in the riparian corridor (Montgomery et al. 1995).

Riparian forests exert strong controls on the microclimate of streams (Naiman and Decamps 1997). Stream water temperatures are highly correlated with riparian soil temperatures, and strong microclimatic gradients appear in air, soil, and surface temperatures, and in relative humidity.

Ecologically, riparian zones: 1) provide sources of nourishment -- allochthonous inputs to rivers and herbivory; 2) control nonpoint sources of pollution, in particular sediment and nutrients, in agricultural watersheds; and, 3) create a complex of shifting habitats, with different spatio-temporal scales, through variations in flood duration and frequency and concomitant changes in water table depth and plant succession (Naiman and Decamps 1997).

Other than a cursory understanding of the presence of plant species, the riparian zones in Theodore Roosevelt National Park are unstudied. More importantly, it is not known how healthy these areas are and if they are functioning properly, thus providing maximum ecological protection to the park's water resources.

Wetlands

Wetlands in Theodore Roosevelt National Park are not as well recognized as the "prairie potholes" of eastern North Dakota, probably because of their limited geographic extent. Nevertheless, they are extremely important in terms of their functions and value. For example, there is growing evidence of a decline in amphibian populations in North America (Phillips 1990; Bury and Major 1997). Although there is not scientific consensus on the cause(s) of the decline in amphibian populations, loss of habitat is generally considered to be a major factor. In a region as semi-arid as Theodore Roosevelt National Park, wetlands are especially critical as amphibian habitat, as well as maintenance of the park's biodiversity. The protection and/or restoration of wetlands in the park should become a priority management objective.

The National Wetlands Inventory of the U.S. Fish and Wildlife Service has identified, classified (according to Cowardin et al. 1979), and mapped wetlands for Theodore Roosevelt National Park. A total of 243 wetlands representing 21 wetland types was identified (Appendix A). Eighty-two percent of these wetlands are associated with the riverine environment, i.e., wetlands in the river channel where the water is usually flowing and bounded on the upland side by upland or channel bank. Rivenne wetlands associated with an unconsolidated shore and having a water regime of temporarily flooded (28 percent of total) or seasonally flooded (40 percent of total) are the two most numerous wetland types in the park. The unconsolidated shore includes all wetland habitats that: 1) have unconsolidated substrates with less than 75 percent areal cover of stones, boulders, or bedrock; and, 2) have less than 30 percent areal cover of vegetation. *Temporarily flooded* refers to surface water that is present for brief periods during the growing season, but the water table usually lies well below the soil surface for most of the season. *Seasonally flooded* refers to surface water that is present for extended periods especially early in the growing season, but is absent by the end of the season in most years.

The third most numerous wetland type (8 percent of total) is a temporarily flooded, emergent, palustrine wetland. Palustrine wetlands are all nontidal wetlands dominated by trees, shrubs, and persistent emergents. The palustrine system was developed to group vegetated wetlands traditionally called by such names as marsh, swamp, bog, fen, and prairie (Cowardin et al. 1979). It also includes the small, shallow, permanent or intermittent water bodies often called ponds. Palustrine wetlands may be situated shoreward of river channels, on river floodplains, in isolated catchments, or on slopes. Emergent refers to erect, rooted, herbaceous hydrophytes. This vegetation is present for most of the growing season in most years; however, the Northern Great Plains climatic fluctuations cause them to revert to an open water phase in some years (Cowardin et al. 1979). These wetlands are usually dominated by perennial plants.

National Wetland Inventory maps are useful, providing a general understanding of the types and potential area of wetlands that are present. However, these maps are often dated, not ground-truthed, and the scale (1:24,000) is inadequate to delineate small wetland types, such as seeps or springs, or detect subtle changes that may occur with respect to habitat boundaries or species composition changes. Due to their limited accuracy and precision, National Wetland Inventory maps are only a first step in a wetland inventory for the park.

In the 1990s, but one spring

The State of North Dakota water quality standards include wetlands in the state's defamation of waters of the state. However, beneficial uses have not been assigned to wetlands, nor have numeric limits been assigned to protect those uses. Wetlands have been provided some water quality protection by the application of North Dakota's narrative standards. These standards prohibit the disposal of garbage, oil, or any toxic pollutant to wetlands. In order to further develop water quality standards for wetland protection, the North Dakota Department of Health published a strategy for the development and ultimate promulgation of wetland water quality standards (North Dakota Department of Health 1996).

Seeps and Springs

Seeps include those springs whose discharge is diffuse and generally immeasurable as there is not a defied channel or opening where the discharge is concentrated. The sources of the water supplying seeps may be local, in which case the seep will respond rapidly to rainfall or drought. Seeps may also be the outlet for underground water that has traveled for long distances. Such seeps do not fluctuate rapidly in response to precipitation. Seeps with well established hydrophilic or phreatophytic vegetation around them are likely to be fed by distant sources. Seeps of this type are important for the vegetation they support, and in turn for the wildlife supported by the vegetation. While the flow is generally small and diffuse, seeps of all kinds can be a source of emergency water supply to wildlife or park visitors by providing enough water in surface troughs or depressions to be useful.

Springs are a special class of seeps and are characterized by well-defined flow path(s) which lend them to capture and development. Springs represent the most important source of water for wildlife in the backcountry, and knowledge of their characteristics, in terms of the temporal distribution of flow and water quality, is important. Like seeps, springs may be fed by bodies of permeable materials recharged by local precipitation, or fed through long pathways from distant recharge points. The water quality of springs and seeps can be a good indicator of distance to the source. Springs and seeps with highly mineralized waters and/or temperatures higher than the mean annual air temperature are likely fed by distant sources, while springs with low mineral content are likely fed from local sources. The distance from the spring or seep to its source is important, because springs with distant sources will have significantly less fluctuation in flow in response to variations in annual precipitation than will springs with local sources.

There are 16 known springs in the park, four in the North Unit and 12 in the South Unit (Table 3). There are innumerable other springs and seeps in the park which have not been inventoried. Ten of these known springs have been ‘developed.’ In the early 1960s, a number of 300- to 500-gallon concrete containers called dish tanks were installed at various spring locations in the park. These tanks are situated at ground level and are either spring or well fed. Dish tanks were placed as part of the wildlife management program, to provide water resources, but more importantly to disperse range use by the large ungulates. These developed water systems require constant maintenance. A number of springs and some seepage areas have been severely degraded by ungulate grazing.

Discharge rates for these springs were taken intermittently by park staff in the 1980s. flow information is scarce. The best available discharge data is from 1988, where all was measured (Table 3).

Table 3. Springs of Theodore Roosevelt National Park and their discharge rates.

Discharge_(gallons/minute)								
Spring	**Park Unit**	**1992**	**1990**	**1988**	**1986**	**1985**	**1983**	**1982**
Achenback	North				40		30	
Stevens	North	13	9	12	15			
Hagen	North	15	30	23	45			
Overlook	North	300		300	300		300	
Ekblom Well	South			103		68	60	
Tomamichael Well	South			*5*		*5*	6	6
Rough Rider Well	South			64	68	68		78
SE Corner Well	South	17	24	28		37		0
Sheep Creek Well	South			180		152		
Sheep Butte Spring	South	7		10		7	75	15
Mike Auney Well	South			126		42	30	138
Lone Tree Spring	South	13		16	35	35	60	30
Big Plateau Spring	South	15		15	19	19	30	60
Biocourt Spring	South	7		2	6	6	4	12
VA Wells	South	6		10		11	15	
Jones Creek	South			140		146	180	168

GROUND WATER

The Northern Great Plains aquifer system underlies most of North Dakota and South Dakota, one-half of Montana, and about a third of Wyoming (Whitehead 1996). The aquifer system is mostly within the Williston Basin, the large structural trough that extends from Montana into North Dakota, South Dakota, and Canada.

The major aquifers of the Northern Great Plains aquifer system are sandstones of Tertiary and Cretaceous age and carbonate rocks of Paleozoic age (Figure 12). These aquifers, along with regional confining units that separate them, form one of the largest confmed aquifer systems in the United States (Whitehead 1996). In some places, local confining units separate the major aquifers into smaller, individual aquifers, but each major aquifer can be treated regionally as a single, large unit.

Unconsolidated glacial and alluvial deposits of Quaternary age, some of which are highly permeable, locally overlie the aquifer system, but are not included in it because the shallow ground water flow system in these deposits is very different from the deep, confined flow in the Northern Great Plains aquifer system.

Regionally, water in the Northern Great Plains aquifer system originates from recharge areas at high altitudes, then moves down the dip of the aquifers and upward again to discharge into shallower aquifers or to the land surface (Whitehead 1996). Much of the water moves into and through the Williston Basin. Water, in the deep, confined, regional aquifers, follows long flow paths and runs from the southwest to northeast. Most of the recharge to the aquifer system is from precipitation, that falls on outcrop areas where the aquifers have been folded or faulted upward and subsequently exposed by erosion, or from snowmelt that runs into streams that cross aquifer outcrops and seeps downward through stream beds into the aquifers. Much of the discharge from the aquifer system is by upward leakage of water into shallower aquifers where the hydraulic head is less than that of the deeper aquifer.

The permeable rocks of the Northern Great Plains aquifer system have been grouped into five major aquifers (Figure 13). From the shallowest to deepest, these are lower Tertiary, upper and lower Cretaceous, and upper and lower Paleozoic. Important ground water sources for Theodore Roosevelt National Park include aquifers from the Lower Tertiary and Upper Cretaceous (Anna 1981). Lower Tertiary aquifers consist of sandstone beds within the Wasatch Formation of Eocene and Paleocene age and the Fort Union Formation or Group of Paleocene age (Whitehead 1996; Figure 12). Both geologic units were deposited primarily in continental environments and consist of alternating beds of sandstone, siltstone, and claystone; both commonly contain beds of lignite in North Dakota. The area of the coal beds is known as the Fort Union coal region, and it contains a major portion of the nation’s coal reserves (Whitehead 1996). The lignite or coal beds, that have been fractured or partially burned after being ignited by lightning or wildfires, form local aquifers. Most water in these aquifers, however, is stored in and moves through the sandstone beds.

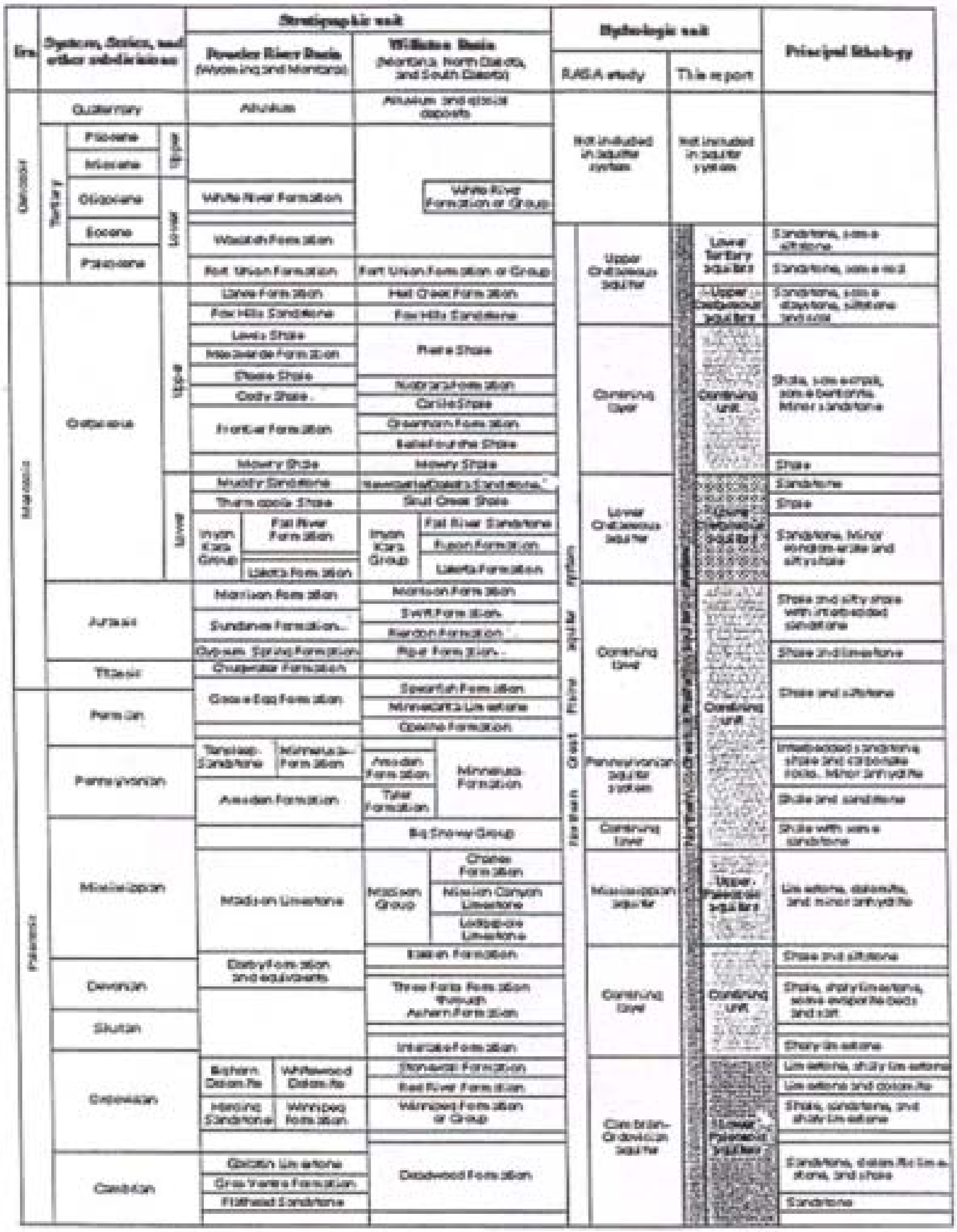

Figure 12. Aquifers of the Northern Great Plains aquifer system (gray shading) and corresponding stratigraphic unit (from Whitehead 1996).

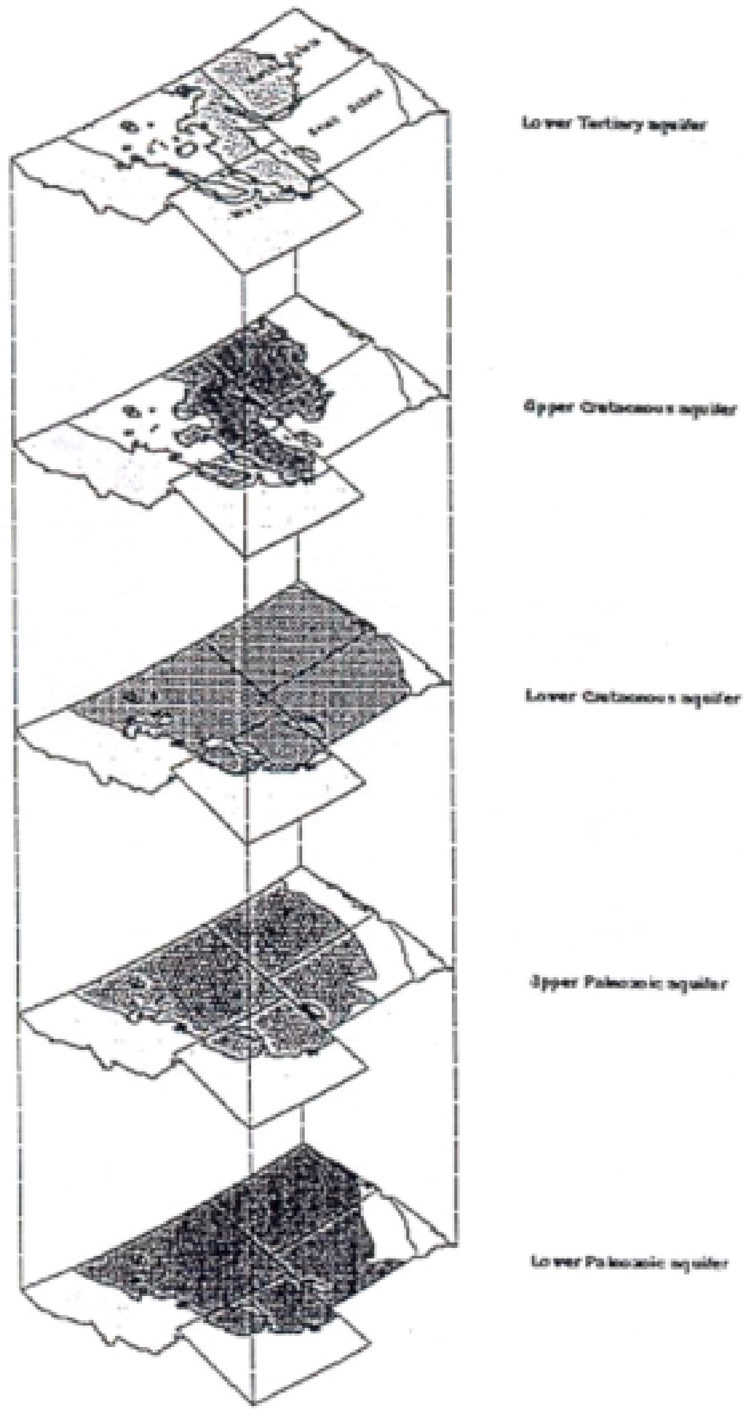

Figure 13. Major overlapping aquifers of the Northern Great Plains aquifer system (from Whitehead 1996).

In western North Dakota, the Fort Union Formation is only about 300 feet thick. A map of the potentiometric surface of the lower Tertiary aquifers indicates that the general movement of water is northward and northeastward from recharge areas in northeastern Wyoming, eastern Montana, and southwestern North Dakota (Whitehead 1996). Water in the lower Tertiary aquifers commonly is under unconfined conditions. Locally, however, the water is confined by clay beds in the upper parts of the aquifers or by till or lacustrine clay where the aquifers are overlain by glacial deposits.

In the Northern Great Plains aquifer system, the upper Cretaceous aquifers are exposed as a wide to narrow band that surrounds the lower Tertiary aquifers (Whitehead 1996). These aquifers consist of sandstone beds in the Lance and Hell Creek formations and the Fox Hills Sandstone (Figure 12). The Lance Formation and the equivalent Hell Creek Formation range in thickness from about 350 to 3,400 feet. Both formations consist of interbedded sandstone, siltstone, claystone, and local thin beds of coal or lignite, all of which were deposited in a continental environment. The underlying Fox Hills Sandstone ranges from about 300 to 450 feet thick and is one of the most continuous water-yielding formations in the aquifer system (Whitehead 1996). The Fox Hills consists primarily of sandstone that was deposited mostly in a deltaic to marine environment and contains local beds of siltstone and shale.

The park obtains ground water primarily from two sources: 1) the Fox Hills-lower Hell Creek aquifer, and 2) the Tongue River aquifer of the Fort Union Group, Upper Tertiary (Butler, pers. comm., 1996). The Fox Hills-lower Hell Creek aquifer displays a hydraulic head of approximately 1,600 feet near the southern boundary of the South Unit of the park (Anna 1981). The resulting potentiometric surface for this aquifer is commonly higher than the overlying aquifer system. The ground water in this aquifer system generally flows from southwest to northeast, with a hydraulic gradient of about 6 feet per mile. Potential yields from this formation are as much as 300 gallons per minute. Flowing wells (wells under artesian pressure) generally will not yield more than 150 gallons per minute.

Ground water movement in the Tongue River aquifer is from southwest to northeast and from south to north. The hydraulic gradient ranges from 10 to 14 feet per mile (Ama 1981). Potential yields from this aquifer have been as much as 250 gallons per minute. Yields from flowing wells are generally less than 10 gallons per minute.

In the South Unit, ground water is produced from both the Fox Hills-lower Hell Creek Formation and the Tongue River Formation. The wells in the Fox Hills Formation are screened at a depth of approximately 1,360 feet below the ground surface, and wells in the Tongue River aquifer are screened at a depth of about 400 to 600 feet below the ground surface (Table 4).

Table 4. Drinking water sources (drilled wells) at Theodore Roosevelt National Park.

WELL	WELL NUMBER	TOTAL DEPTH (feet)	PARK UNIT
North Unit Headquarters	00193	400	North
Cottonwood Campground	03680	1365	South
Medora Headquarters	01198	1343	South
Juniper Campground	01197	420	North
Peaceful Valley Ranch	01191	1180	South
Rasmussen	01192	360	South
Peaceful Valley Picnic Area	01194	424	South
Painted Canyon Overlook	Unassigned	1928	South
Roundup Horse Camp	05017	1320	South

Source: Theodore Roosevelt National Park files.

Recharge to the both aquifers is very limited and is easily exceeded by the discharge from the aquifer, which occurs mainly in the form of withdrawal of water from wells (Ama 1981). Wells in both formations are experiencing a decrease in head. Water levels in the Fox Hills-Hell Creek aquifer are declining at a rate of up to 1.9 feet per year and an average rate of 0.7 feet per year (North Dakota State Water Commission 1995). Eventually flow will cease from some of these wells.

Alluvial deposits containing aquifers of potential importance occur in the Little Missouri River valley (Anna 1981). The alluvium is characterized by silty clay in the upper few feet, which contains local patches of sand and becomes sandier near the stream channel. The lower part of the deposits commonly consist of 10 to 15 feet of gravel that is underlain by bedrock. This alluvial aquifer recharges from precipitation, high streamfiow, floods that inundate the floodplain, and drainage of the alluvium of small ephemeral streams hydrologically connected to the main alluvial aquifer. The Little Missouri River valley aquifer generally is less than 1 mile wide, with a mean thickness of 12 feet. Potential yields from properly constructed wells are generally less than 50 gallons per minute (Anna 1981).

WATER QUALITY

Surface Water

From a regional perspective, sediment, nutrient loading (primarily nitrogen and phosphorus), and pathogens from urban and agricultural waste are the primary causes of surface water quality impairment in the Northern Great Plains. Table *5* provides a comparison of national surface water quality with the Northern Great Plains. On average, the number of streams impaired in the Northern

Great Plains states is greater than the number impaired nationwide. Agricultural activity in the Northern Great Plains states may be a significant source of impairment.

Table 5. National surface water quality summary and comparison with the Northern Great Plains states.

	Fully Supporting Designated Use	Cause of Impairment			Agriculture as Impairment
		Sediment	Nutrient	Pathogens	
Nationwide	70%	42%	27%	19%	*55%*
Northern Great Plains	60%	54%	39%	32%	77%

Source: Modified from Northern Prairie Wildlife Research Center 1998.
Note: "Fully Supporting Designated Use" refers to the percentage of assessed water. Only 29 percent of the nation's total river and stream miles was assessed. Also, the three leading causes of impainnent are listed. The percentage refers to the fraction of impaired stream miles affected by the indicated cause.

The U.S. Environmental Protection Agency has generated an Index of Watershed Indicators (1998) for both the Lower Little Missouri River watershed, which includes the North Unit, and the Middle Little Missouri River watershed, which includes the South and Elkhorn units. This index of Watershed Indicators is based on subjective scoring of 14 criteria that assesses current watershed condition and vulnerability (Figure 14). These criteria are then combined into an overall watershed score that ranges from 1 (better water quality) to 6 (more serious water quality problems).

For the Lower Little Missouri River watershed, insufficient data exist to make an assertion of condition or vulnerability (U.S. Environmental Protection Agency 1998a). This is primarily due to a lack of data for five criteria (Figure 14). However, sufficient data exist to show four problem areas:
fish consumption advisories; wetland loss; wetland aquatic species at risk; and, an agricultural runoff index.

The Middle Little Missouri River watershed has an overall watershed score of '3' which equates to "less serious water quality problems - low vulnerability to stressors such as pollutant loadings" (U.S. Environmental Protection Agency 1998a). The same problem areas exist as those for the Lower Little Missouri River watershed; however, insufficient data is less of a problem (Figure 14).

The water quality standards for the State of North Dakota includes all rivers and streams as well as 180 lakes and reservoirs (North Dakota Department of Health and Consolidated Laboratories 1991). Beneficial uses are defined, and narrative and numeric water quality standards are set to ensure those uses are protected. Present beneficial uses defined for the state's rivers and streams include:
agriculture, industry, domestic and municipal water supply, recreation, fishing (warm, cool, cold water) and aquatic life.

Major rivers are classified as either I, IA, or II. These classifications mean beneficial uses can include aquatic life, fishing, recreation, drinking water supply, agriculture and industry. The Little Missouri River is classified as Class II, which includes aquatic life, warm water fishing, and recreation as

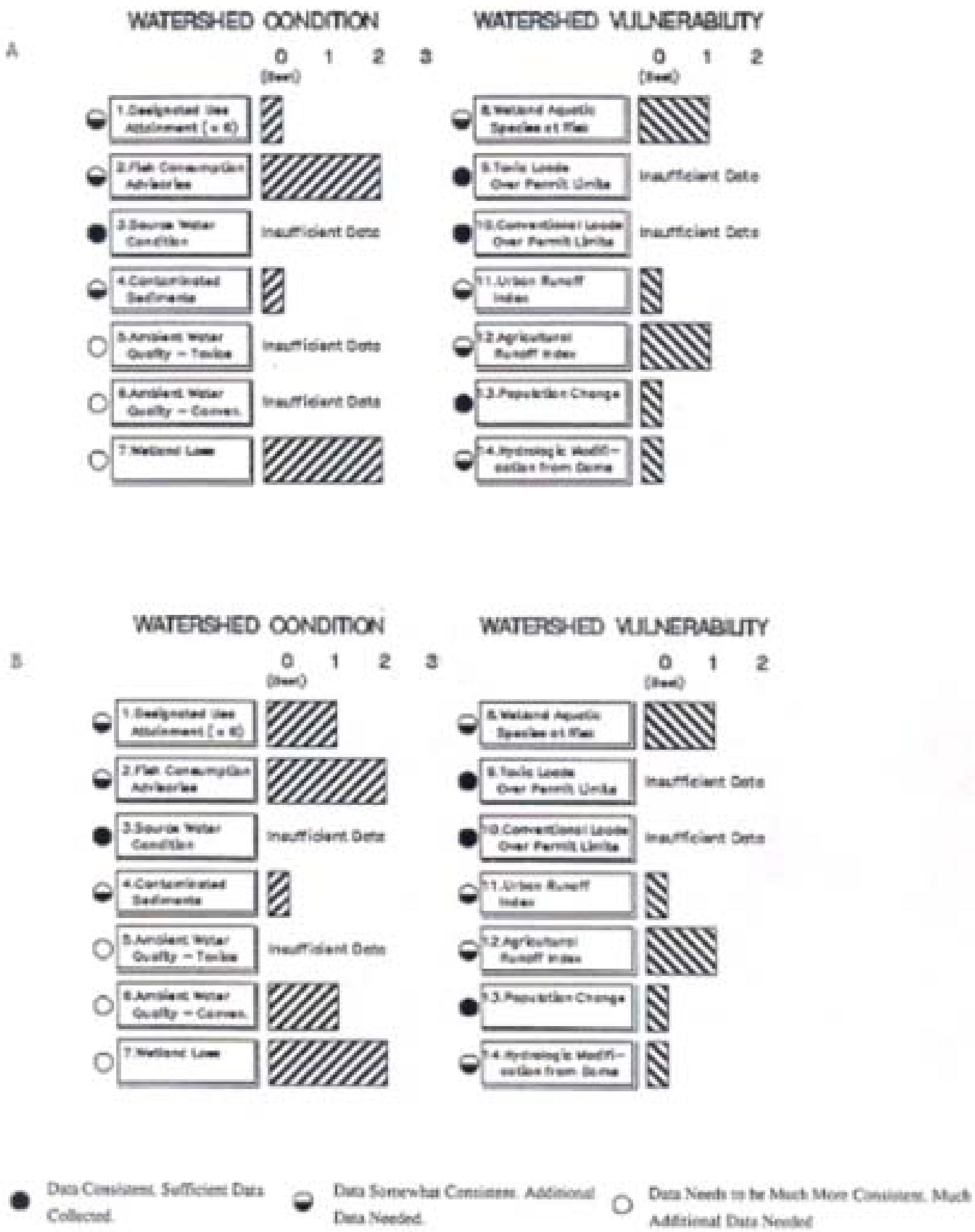

Figure 14. Criteria and criteria scores for the U.S. Environmental Protection Agency's Index of Watershed Indicators for the lower (A) and middle (B) Little Missouri River watersheds (after U.S. Environmental Protection Agency web site at http://www.epa.gov/surf/IWI).

beneficial uses (North Dakota Department of Health and Consolidated Laboratories 1993; see Appendix B). Small rivers and streams listed in the standards and all streams not specifically mentioned are designated as Class iii streams. Beneficial uses for these streams include aquatic life, recreation, agriculture, and industry.

Water quality in the Little Missouri River is variable and related to flow. During low flow periods, most of the water in the river is derived from ground water. Turbidity is normally low due to lack of surface runoff. Also, due to high salt content in the soil and parent rock material, the water normally has high background concentrations of salts (measure is total dissolved solids which equates to a measure of salinity). During high flow, this mineralized water is greatly diluted with runoff from precipitation. Badlands soils are highly erodible, and during periods of intense rainfall and/or high flow, streams may be unusually turbid with high sediment loads.

The National Park Service (1997) conducted surface water quality retrievals for Theodore Roosevelt National Park from six of the U.S. Environmental Protection Agency's national databases, including STORET. The results of these retrievals for the study area (limits included 3 miles upstream and 1 mile downstream of park boundaries) cover the years 1949 to 1996 and include 76 water quality monitoring stations (Figure ~ in pocket; Figures 15 and 16), one industrial municipal discharge site, no municipal water supply intakes, one water impoundment, and nine active or inactive U.S. Geological Survey gaging stations. Most (43) of the monitoring stations are outside park boundaries and represent either older one-time or intensive single-year efforts by collecting agencies or discontinued stations. The data from these stations show historical water quality conditions and may be useful, in a limited way, for displaying historical trends, but are of little use in an assessment of current water quality.

In addition, out of a total of 19,534 water quality observations for the above time period, 83 percent were taken at only two monitoring stations -- 60 percent at the Little Missouri River at Watford City and 23 percent at the Little Missouri River at Medora. However, overall these data do indicate that surface waters within the study area have been impacted by human activities, including wastewater discharges, grazing, and oil and gas activities.

Table 6 summarizes the results of the National Park Service (1997) study based on existing database retrievals. Eight parameters (turbidity, total coliform, fecal coliform, total sulfate, beryllium, copper, lead, and zinc) exceeded their standard more than 20 percent of the time. Of the 678 miles of North Dakota's rivers with elevated levels of toxins, 306 miles were from the Little Missouri River (North Dakota Department of Health and Consolidated Laboratories 1993). The presence of turbidity, sulfate and several metals which exceed criteria is likely explained by runoff from soils and deposits associated with the surficial geology of the Little Missouri River basin (North Dakota Department of Health 1996). Agricultural practices, petroleum exploration, and extraction activities in the area exacerbate the problem. However, the data are limited, and water quality problems should be further defied by more detailed study before final conclusions are drawn (Ell 1998).

Additionally, work is underway to define impaired stream segments and their sources under section 303(d) of the Clean Water Act. The timing of this work is unclear at this point. Park staff should contact the State of North Dakota before undertaking water quality monitoring so that efforts are not duplicated between the park and the state. Park officials should also contact other federal agencies responsible for 303(d) activities surrounding park lands for coordination purposes.

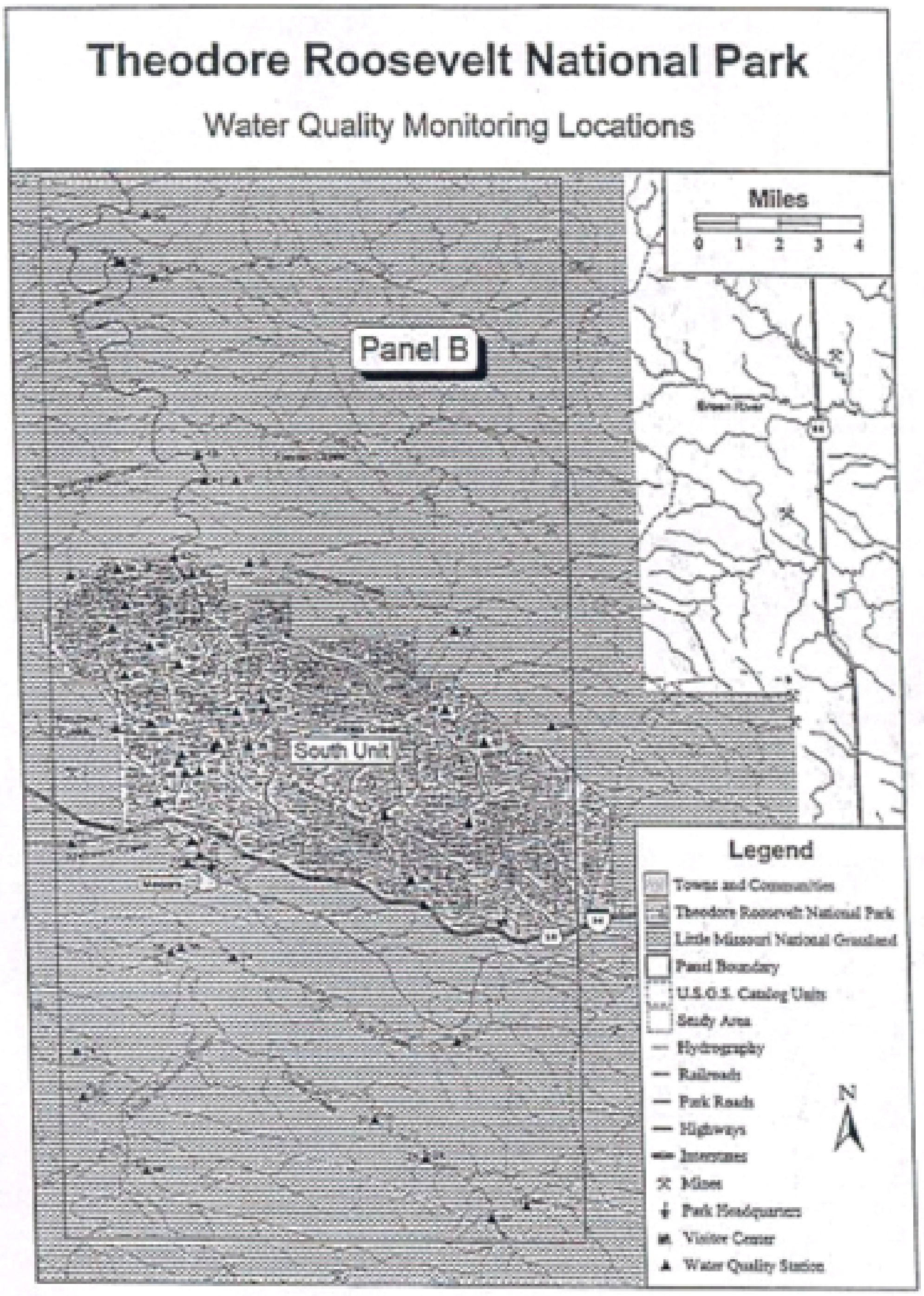

Figure 15. Location of water quality monitoring stations for the South Unit, Theodore Roosevelt National Park (from National Park Service 1997).

Table 6. Summary of water quality monitoring data from National Park Service (1997) study for Theodore Roosevelt National Park.

Surface Water Quality Parameter Measured For The Little Missouri River

	Dissolved Oxygen	pH	Turbidity	Total Coliform	Fecal Coliform	Fluoride Concentration	Total Sulfate Concentration	Arsenic Concentration	Barium Concentration
Range of Concentration	0.9 - 15	3.1 - 9.2	0.0 - 15000	0 - 58000	0 - 38000	0 - 5.2	0 - 5400	0 - 447	0 - 2200
Standard	≤ 4 mg/l	6.5 to 9.0 Standard Units	50 Turbidity Units	1000 CFU/MPN/ 100 ml	200 CFU/MPN/ /100 ml	4 mg/l	250 mg/l	50 µg/l	2000 µg/l
Number of Exceedances	3	5	116	37	54*	2	384	11	2
Sampling Period	1968 to 1994	1969 to 1996	1971 to 1994	1968 to 1976	1971 to 1994	1949 to 1995	1949 to 1995	1974 to 1995	1974 to 1994
Number of Measurements	794	3811	182	98	220	231	455	159	161
Number of Measurement Stations	3	32	24	2	4	47	51	3	3

	Beryllium Concentration	Cadmium Concentration	Chromium Concentration	Copper Concentration	Lead Concentration	Mercury Concentration	Nickel Concentration	Natural Uranium Concentration	Zinc Concentration	Temperature
Range of Concentration	0 - 20	0 - 20	0 - 480	0 - 1000	0 - 500	0 - 2.4	1 - 830	2.8 - 4000	0 - 1300	0 - 27
Standard	4 µg/l	3.9** µg/l and 5.0*** µg/l	100 µg/l	18 µg/l	15† µg/l and 82†† µg/l	2‡ µg/l and 2.4‡‡ µg/l	100 µg/l	20 µg/l	120 µg/l	30° C
Number of Exceedances	13	9/9	13	58	30/30	3/1	15	1	36	Occasionally
Sampling Period	1974 to 1993	1974 to 1992	1974 to 1992	1974 to 1992	1974 to 1995	1974 to 1995	1978 to 1994	1983 to 1984	1974 to 1992	
Number of Measurements	58	147	154	159	149	123	90	1	156	
Number of Measurement Stations	3	3	3	3	3	3	2	14	3	

* 63% of these exceedances between 1972 through 1992 were reported in the Little Missouri River at Medora

** acute freshwater criterion

*** drinking water standard

† drinking water criterion

†† acute freshwater criterion

‡ drinking water criterion

‡‡ acute freshwater criterion

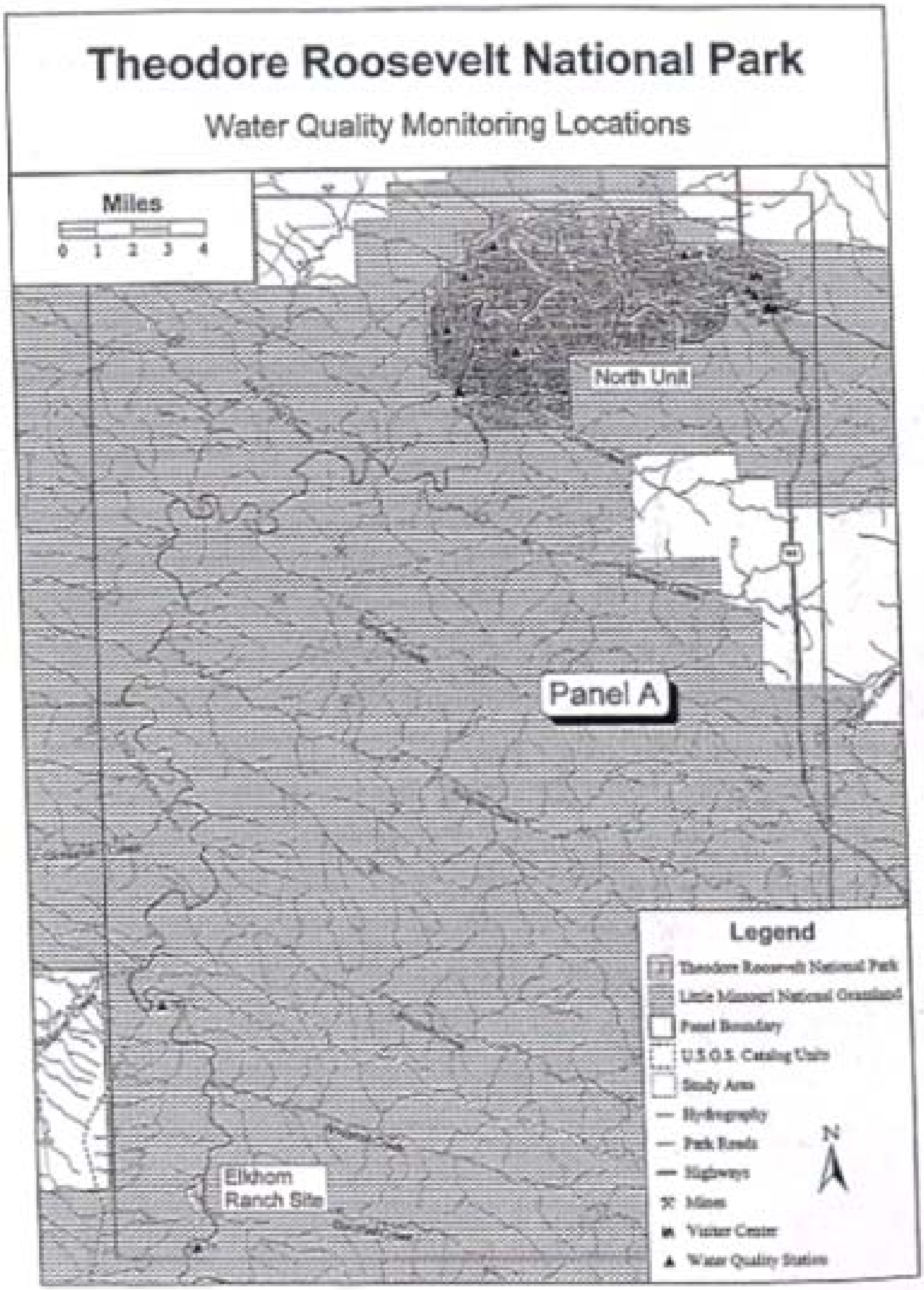

Figure 16. Location of water qualilty monitoring stations for the North and Elkhorn units, Theodore Roosevelt National Park (from National Park Service 1997).

Ground Water

Human activities can degrade the quality of ground water. For example, if an uncased well is drilled and penetrates an aquifer containing saline water under artesian pressure, then the saline water can rise through the borehole and spread outward to contaminate shallower, freshwater aquifers (Whitehead 1996). This type of contamination is possible only where the hydraulic head in the shallower aquifers is less than that in the aquifer that contains saline water. In areas where coal or metallic ores have been mined, precipitation may fall or percolate into mine tailings or spoil piles where wastes have been stacked. Similarly, ground water can move laterally into the wastes, dissolve mineral material, and carry contaminants into underlying and adjacent uncontaminated ground water. Large concentrations of sulfate, iron, and other metals, or radionuclides can result from the leaching of mine tailings.

Other human activities that can affect the quality of ground water include: the application of pesticides and fertilizer to cultivated land; disposal of human wastes in septic tanks, cesspools, or wastewater treatment plants; disposal of liquid and solid wastes in landfills; storage of petroleum or other liquids in leaky underground tanks; and, disposal of oil and gas production water or liquid industrial wastes in injection wells or surface storage ponds

The quality of ground water is the most important ground water problem in the Williston Basin (Whitehead 1996). Highly mineralized water is present in shallow and deep aquifers. In most aquifers, the dissolved minerals in the water are from partial dissolution of aquifer minerals. In some, mineralized water has leaked into the aquifer from shallower or deeper aquifers. The primary ground water concerns are salinity and contamination of the shallow alluvial aquifers from nitrates and pesticides. (Generally, shallow alluvial aquifers along major drainage systems are more vulnerable to contamination.) Fertilizer and pesticide leaching is a primary threat to the region’s ground water quality because of the increased use over the last three decades.

Water in the upper Cretaceous aquifers usually contains less than 3,000 milligrams per liter (mg/l) of dissolved solids. Some small areas in North Dakota, however, have concentrations as great as 10,000 mg/i (slightly saline is 1,000 to 3,000 mg/i; moderately saline is 3,000 to 10,000 mg/I; very saline is 10,000 to 35,000 mg/i) (Whitehead 1996). Throughout large parts of the Williston Basin, ground water concentrations of dissolved solids exceed the secondary maximum contaminant level of 500 mg/i recommended for drinking water by the U.S. Environmental Protection Agency. In some places, water with dissolved solids concentrations of 2,000 mg/i or more is used for human and livestock consumption (because no fresher water is available). The major dissolved ions in water from the upper Cretaceous aquifers are sodium, sulfate, and bicarbonate; locally, calcium and magnesium may be dominant.

The Fox Hills-lower Hell Creek aquifer is considered the best overall aquifer for its yield and quality, as well as the fact that it flows at land surface in many locations (Anna 1981). Based on limited samples, Anna determined that total dissolved solids concentrations for this aquifer ranged from 887 to 1,720 mg/i with a mean of 1160 mg/i. Water from this aquifer is within North Dakota water quality standards; however, total dissolved solids concentrations exceed recommended levels. This is due to high concentrations of sodium in the water. Alluvial aquifers along the Little Missouri River generally have total dissolved solids concentrations that are moderately saline (Anna 1981). The high sodium content, in relation to other parameters, results in very soft water that is generally unsuitable for irrigation. Also, individuals on sodium-restricted diets may need to limit their intake of the water. As the saturated thickness of this aquifer continues to decrease due to water withdrawal, the concentrations of problematic constituents are expected to increase.

Water from the Tongue River aquifer is hard (hardness of 20 to 760 mg/i with a mean of 280 mg/i) in the first 200 feet of saturated thickness and generally soft (hardness of 4 to 420 mg/i with a mean of 38 mg/i) when more than 200 feet deep (Ama 1981). Total dissolved solids for water greater than 200 feet ranged from 270 to 1,880 mg/i with a mean of 1,100 mg/i.

Roberts (1994) studied naturally occurring uranium in ground waters of southwestern North Dakota. In 199 1-92 Roberts sampled 24 wells in Billings County that had a mean depth of 44 feet with a mean uranium concentration of 39.1 ug/l; nine wells exceeded the 20 ug/l maximum concentration level as proposed by the U.S. Environmental Protection Agency. Roberts also conducted a retrospective analysis of two studies conducted from 1975-77. During this period, 264 wells were sampled with an average depth of 123 feet and mean uranium concentration of 41.4 ugh; 88 wells exceeded the 20 ug/i maximum concentration level. Although the park does not currently have any shallow wells as part of its water supply systems, problems associated with naturally occurring uranium in ground waters of southwestern North Dakota should be considered before shallow wells are developed. Currently, Region IX of the U.S. Environmental Protection Agency has a preliminary remediation goal for uranium in drinking water of 0.0092 ug/l; the maximum contaminant level goal for drinking water is zero.

WATER RIGHTS

State water rights in North Dakota are based on the Doctrine of Prior Appropriation. Under this doctrine, the party who first puts the water to a beneficial use has a prior water right against all other appropriators, i.e., “first in time, first in right”. Beneficial use, as defined by the state, includes irrigation, domestic stock watering, recreation, fish and wildlife, as well as municipal, commercial, industrial, and mining. An appropriative water right is a property right, which grants the owner the right to use but not own the water. Under state law, water rights can be bought or sold. These transactions are constrained when there is a transfer for uses: in other locations; for different purposes; at differing times; or, involving changes in the points of diversion or return.

In North Dakota, both surface and ground waters are subject to appropriation. For domestic, livestock, fish, wildlife, or recreational uses, the application of water to a beneficial use is all that is required to establish a right. Generally, a diversion or some means of controlling the water is required. A permit must be obtained from the State Engineer to appropriate water for municipal, commercial, industrial, mining, or irrigation purposes.

Federally reserved water rights arise in connection with lands put in reservation by the Federal Government for a particular purpose, such as establishing a National Park. When the Federal Government reserves land, it also reserves, by implication, enough unappropriated water to accomplish the purposes for which Congress or the President authorized its creation, without regard to the limitations of state law. Generally, whether the water is or is not actually put to use, the rights vest, as of the reservation date, and are superior to the rights of those who begin use of water afterward. Federally reserved rights may include water for consumptive uses, such as domestic and irrigation, as well as nonconsumptive uses, such as the maintenance of instream flow to support the purposes for which the reservation was established.

General adjudications are the means by which the Federal Government claims its reserved water rights as provided by the Act of June 10, 1952 (66 Stat. 560, 43 U.S.C. 666) -- the McCarran Amendment. Commonly, in an adjudication, all water users on a river and its tributaries must claim their water rights. After considering evidence and testimony, the court issues the decree(s) setting forth the rights within the adjudicated area. Adjudications are generally in the jurisdiction of state courts. Federal courts may also have jurisdiction in certain instances.

Research on the development and use of federal and non-perfected water rights located within or outside of Theodore Roosevelt National Park was completed in 1964. At that time, inspection of records at the State Engineer's Office in Bismarck, N.D., and the courthouse records in Billings and McKenzie counties revealed no record of any wells other than the eight water rights filed by the National Park Service in 1964. These eight filings cover the public water sources used in the park and have been kept current through the annual use report to the state. Additional wells for public use at Cottonwood Campground and Roundup Horse Camp are the only permits added since 1964. A list of existing and abandoned water wells is included in the 1964 report. There is no record of application for water rights except for those wells developed for public use. None of the wells have been adjudicated, nor have water rights for any surface waters been secured. It should be noted that the courts have determined that the Little Missouri River is not a navigable river and that adjacent landowners have jurisdiction over the riverbed.

AQUATIC BIOLOGY

Fish

The central and northern Great Plains region (essentially the Missouri River drainage) is home to approximately 200 species of fish (Rabeni 1997). Minnows (Cyprinidae), perches (Percidae), suckers (Catostomidae), and catfishes (Ictaluridae) comprise about 70 percent of the native fish fauna. Ecological factors are apparently more important in determining fish distribution than drainage boundaries in this region. Commonly, species inhabit parts of many drainages, while only a few species are present throughout a single drainage. Fish communities of the Missouri River drainage tend to decrease in species richness both northward and westward, primarily in response to increases in flow variability, turbidity, and temperature extremes, and a decrease in habitat diversity (Rabeni 1997).

Historic information on the aquatic environments and resources is limited for the Little Missouri River drainage. The first to document fishes of the Missouri River was the Lewis and Clark Expedition (1804-1806). Fish surveys of the Missouri River's western tributaries did not occur until the mid-1800s; however, scientific investigation was only an incidental aspect of western expansion until well into the twentieth century (Reigh and Owen 1979).

Hankinson (1929) was the first to report on the fishes of the Little Missouri River. Seventeen species were reported with walleye *(Stizostedion vitreum),* sauger (S. *canadense),* and white sucker *(Catostomus commersoni)* the most abundant large fish. The plains minnow *(Hybognathus placitus),* flathead chub *(Platygobio gracilis),* and goldeye *(Hiodon alosoides)* were the abundant small species.

The Garrison Dam pre-impoundment survey in 1950 (Personius and Eddy 1955) revealed a shift in species distribution and abundance in the Little Missouri River from that of Hankinson (1929). Channel catfish *(Ictaluruspunctatus)* and sauger were the only sport fish collected. The white sucker, flathead chub, and river carpsucker *(Carpiodes carpio)* were the most abundant species throughout the drainage. A total of 18 species was reported, 17 of which were considered part of the original fauna (excluding the carp, *Cyprinus carpio).* Four additional species were found in tributaries of the Little Missouri River and were considered introduced game fish. These species are the largemouth bass *(Micropterus salmoides),* pumpkinseed sunfish *(Lepomis gibbosus),* black crappie *(Pomoxis nigromaculatus),* and creek chub *(Semotilus atromaculatus).*

The North Dakota Game and Fish Department collected fish from 17 stations in the Little Missouri River from 1971 to 1974 and resurveyed the river in 1984 (Duerre 1986). The latter study collected a total of 13 species. Several species of note (e.g. walleye, crappie, and black bullhead, *Ictalurus melas)* were not collected while the western silvery minnow *(Hybognathus argyritis),* emerald shiner *(Notropis atherinoides),* and green sunfish *(Lepomis cyanellus)* were reported for the first time. Sauger and *Ictalurus* spp. were the most abundant and widely distributed species.

To date, Reigh and Owen (1979) have provided the most comprehensive documentation of the fish community within the Little Missouri River basin, which included the relative abundance of each species. They collected 32 species, of which the most abundant were (in decreasing order) the flathead chub, *Hybognathus* sp., sand shiner *(N. stramineus),* stonecat *(No~urusflavus),* longnose dace *(Rhinichthys cataractae),* channel catfish, and fathead minnow *(Pimephalespromelas).* Reigh and Owen determined that species are either limited in number in the Little Missouri River drainage or do not occur in other tributaries of the Missouri River. These differences in species composition and abundance are probably a result of the high flow variability, high turbidity, constantly shifting bottom, and almost complete lack of aquatic vegetation in the Little Missouri River (Reigh and Owen 1979). Table 7 lists broad habitat preferences (mainstem versus tributary) and frequency of occurrence (common versus rare) for fish species collected by Reigh and Owen within the Little Missouri drainage in 1978.

The most recent assessments of the fish fauna of the Little Missouri River were completed in 1993 (Peterka 1993; Kelsch 1993). Peterka sampled the fish community at 11 stations during June and September within the Little Missouri River drainage north of Medora. Three of these stations were on the Little Missouri River within the boundaries of Theodore Roosevelt National Park. Eleven species were collected: goldeye, longnose dace, channel catfish, fathead minnow, plains minnow, western silvery minnow, sauger, creek chub, flathead chub, white sucker, and brook stickleback. In two different samplings, a total of 11 species were collected from two stations in the South Unit. Seven species were collected from the one station in the North Unit. Dominant species across all sampling stations and dates included flathead chub, plains minnow, longnose dace, goldeye, and white sucker. Kelsch (1993) sampled fish from Marmarth to Medora, N.D., on the Little Missouri River. He found the Mississippi silvery minnow *(Hybonathus nuchalis).* Before this discover, this species was found in North Dakota only in the Pembina River (Peterka 1991).

Duerre (1986) attributed the change in the last 80 years to the Little Missouri River fish fauna to land use practices within the drainage that have further reduced the habitat heterogeneity in a system already habitat limited. Ground cover has been reduced and erosion potential increased by intensive grazing and cultivation. Woody tributary draws have been overgrazed by cattle, damaging the understory and reducing their value for retaining runoff water. Similarly, riparian and floodplain

Table 7. Little Missouri River fish fauna circa 1978. The terms ‘common’ and ‘rare’ refer to frequency of occurrence and not abundance.

Common Species in the Mainstream of the Little Missouri River	
goldeye *(Hiodon alosoides)*	longnose dace *(R/4zichthys cataractae)*carp
*(Cyprinus carpio)**	river carpsucker *(Carpiodes carpio)*western silvery
minnow *(Hybognathus argyritis)*	channel caffish *(Ictalurus punctatus)*plains
minnow *(Hybognathus placitus)*	stonecat *(Noturusfiavus)*sturgeon chub
(Macrohybopsis gelida)	sauger *(S. canadense)*flathead chub *(Piatygobio*
gracilis)	white sucker *(Catastomus commersoni)*
Rare Species in the Mainstream of the Little Missouri River	
northern pike *(Esox lucius)*	burbot *(Lota iota)*sand shiner *(N. stramineus)*
	green sunfish *(Lepomis cyaneiius)**longnose sucker
(Catostomus catostomus)	walleye *(Stizostedion vitreum)*black buflhead
(Ictalurus melas)	freshwater drum *(Apiodinotus grunniens)*emerald
shiner *(Notropis atherinoides)*	smalhnouth buffalo *(Ictiobus bubalus)*
Species Found Only in Tributaries to the Little Missouri River	
lake chub *(Couesius plumbeus)*	white sucker *(Catostomus commersoni)*brassy minnow
(Hybognathus hankinsoni)	shorthead redhorse *(Moxostoma*
*macrolepidotum)*golden shiner *(Notemigonus crysoleucas)* brook stickleback *(Cuiaea*	
*inconstans)*fathead minnow *(Pimephales promelas)* bluegill *(Lepomis macrochirus)**Iowa	
darter *(Etheostoma exile)*	

*Native or exotic species

Source: Modified from Reigh and Owen (1979).

vegetation along the mainstream channel has been cleared or overgrazed. The reduction of ground cover on the watershed has increased peak flows, shortened flow periods, increased silt loads, and reduced percolation that would prolong tributary flows.

Presently, there are no federally listed threatened or endangered fish species that occur in the Little Missouri River drainage. As of February 28, 1996, the plains minnow, western silvery minnow, and flathead chub are no longer listed as candidate species by the U.S. Fish and Wildlife Service. These species are now considered “species of management concern” by the Service. However, at the state level, the flathead chub is classified as SC1 (native species whose status is questioned due to suspected problems with abundance or distribution), and the western silvery minnow is SC2 (native species whose status is questioned due to limited and/or inconclusive historical citations) (Dakota Chapter of American Fisheries Society 1994).

The sturgeon chub is one of two candidate fish species (state threatened) in the Little Missouri River drainage (Power and Ryckman 1998). The most recent sturgeon chub collections in North Dakota occurred in 1977 (Reigh and Owen 1979) and 1984 (Duerre 1986) on the Little Missouri River. Reigh and Owen (1979) collected this species all along the Little Missouri River, including Theodore Roosevelt National Park. Overall, this species ranked eighth out of 32 species in relative abundance.

The fact that sturgeon chub were not collected in 1993 (Peterka 1993 and Kelsch 1993) may indicate a further decline in the status of this species within the Little Missouri River basin.

The Missouri River Fish and Wildlife Management Assistance Office of the U.S. Fish and Wildlife Service in Bismarck, North Dakota, has developed a program to restore the sturgeon chub in the Little Missouri River (U.S. Fish and Wildlife Service 1997a; 1998). Approximately 300, hatchery-reared sturgeon chub were released into the Little Missouri River in the South Unit during the summer of 1998. An "Investigator's Annual Report," which describes this reintroduction, will be developed by the Management Assistance Office for the park by the end of 1998 (King 1998).

The sicklefin chub, a candidate species (state endangered), historically occurred in the Little Missouri River (Personius and Eddy *1955;* Power and Ryclcman 1998), but has not been seen for over 40 years. It is possible that this species could still be found in the Little Missouri River; however, it is unlikely because it inhabits large, swift, and deep rivers (Pflieger 1975).

Although the Little Missouri River is essentially a stream primarily suited for small, nongame species, game fish have and can exist in the area throughout the year (Duerre 1986). Wet years combined with high water tend to be more productive for game fish. Migration from Lake Sakakawea will peak during these conditions providing a fishery from early spring to late summer. The area is rather unique in that spring runoff, if not great and turbid, will provide a pike and sauger run, while the later high flows caused by heavy rains will encourage movement of catfish.

Amphibians and Reptiles

Ninety species of reptiles and 34 species of amphibians occur in the prairie region (Corn and Peterson 1997). Corn and Peterson noted that this herpetofauna is composed of a complex mix of eastern and western species. Few of these species actually evolved in or are restricted to the central part of North America. There are two strong decreasing gradients in species richness, south to north and east to west. These gradients are determined by climate and associated vegetation gradients.

A comparison of species richness by habitat association in North Dakota shows almost a 1:1 ratio of species associated with prairie habitats versus species associated with forest habitats (Corn and Peterson 1997). The distribution of amphibians and reptiles in North Dakota has not been well documented. Previous studies by Wheeler and Wheeler (1966), Hibbard (1972), and Seabloom, et al. (1978) showed that the herpetofauna of North Dakota is depauperate compared to other areas.

Hansen et al. (1980) and Hopkins (1983) studied the herpetofauna of Theodore Roosevelt National Park in attempts to better understand the species distributions and habitat affinities in southwest North Dakota. In both studies, 13 species were collected, six amphibians and seven reptiles. Three species of amphibians, tiger salamander *(Ambystoma tigrinum),* northern leopard frog *(Rana pipiens),* and boreal chorus frog *(Pseudacris triseriata)* were primarily found in aquatic habitats. The tiger salamander was rarely observed; however, Hopkins noted that the overflow at wildlife watering tanks and permanent ponds probably provide potential breeding sites. All collections of the boreal chorus frog were made near a source of permanent water, usually small marshes. The northern leopard frog was collected along stream courses, but it was seen here less frequently than around ponds and marshes.

Two species of reptiles, racer *(Coluber constrictor)* and plains garter snake *(Thamnophis radix),* were also associated with aquatic habitats; however, the plains garter snake was the only snake seen regularly near aquatic habitats. Two amphibian species, plains spadefoot *(Scaphiopus bomb~frons)* and Woodhouse's toad *(Bufo woodhousei),* were collected in floodplain areas with deciduous woodlands. Similarly, four reptilian species, racer, western hognose snake *(Heterodon nascicus),* gopher snake *(Pituophis melanoleucus),* and western rattlesnake *(Crotalus viridus)* were also collected in deciduous floodplain habitat. Four other species may be found in the park: painted turtle *(Chiysemys picta);* snapping turtle *(Chelydra serpentina);* red-sided garter snake *(Thamnophis sertalis),* and Canadian frog *(Bufo hemiophrys)* (Seabloom Ct al. 1978; Hansen et al. 1980; and Hopkins 1983).

Invertebrates

The paucity of information on aquatic invertebrates (as well as aquatic plant/algae communities) is somewhat surprising considering the opportunities for biological discovery. For example, springs tend toward a uniform temperature, usually the mean annual air temperature of the region (Hynes 1970). Therefore, springs generally provide uniform conditions in areas that are subject to seasonal changes. In these spring environments, relictual species may have survived and many crenobionts (species confined to springs) can occur far outside their normal geographic range (Hynes 1970).

With the exception of a study by Cvancara (1983), the invertebrate community of aquatic systems in the park and for that matter in all of southwest North Dakota, is unstudied. Cvancara (1983) conducted a survey of the aquatic mollusks (mussels, pill clams, and snails) of North Dakota. Distribution maps reveal the following species in the Little Missouri River drainage: *Anodonta grandis* (mussel), *Lasmigona complanata* (mussel), *Psidium compressum* (pill clam), *Sphaerium stiatinum* (pill clam), and *Ferrissia rivularis* (snail).

PARK OPERATIONS

The resource management staff resides within the Resource Management and Visitor Protection Division and reports to the Superintendent through the Chief Ranger. The staff consists of a Resource Management Specialist, a Geographic Information Systems Technician, and a Biological Technician. Specific programs related to water resource issues have been identified in the current Resources Management Plan for the park (National Park Service 1998). However, none of these programs has been funded.

Planning Issues and Recommendations

WATER RESOURCE PLANNING ISSUES AND RECOMMENDATIONS

The National Park Service Water Resources Division, U.S. Environmental Protection Agency, and Theodore Roosevelt National Park personnel held an initial water resources scoping meeting at Theodore Roosevelt National Park in October, 1996. The purpose of this meeting was for Water Resources Division and U.S. Environmental Protection Agency personnel to gain familiarity with the park's water resources, and identify and prioritize water resource issues and management concerns. Subsequent discussions were held with other federal and state personnel and county officials, as well as other water resource professionals in order to further refine potential water resource issues and develop management actions to address these issues.

A total of 13 water resource issues are discussed below. These 13 issues have been prioritized into four high priority and eight medium priority issues. Nine management actions or project statements (Appendix C) were developed for only the high priority issues. This was considered prudent, given current funding and personnel constraints, i.e., the park would only be capable of addressing high priority issues over the lifespan of this plan. However, where applicable, recommendations are provided under medium priority issues. These recommendations provide the park the ability to respond to issues if priorities shift in the future. Additionally, a few of the project statements address both high and medium priority issues.

HIGH PRIORITY ISSUES

Lack of Baseline Data on Aquatic Resources

Present and expected development in that part of the Williston Basin containing the Little Missouri River has the potential to seriously impair surface and ground water quality, reduce surface and ground water quantity, and negatively affect biological resources in the park. Extensive oil and gas development such as various types of wells, storage tanks, pipelines, and transportation corridors surround the park, and, in some instances, cross the park. Such developments, and their associated infrastructures, create a potential for oil and chemical contamination. With approximately 1,600 wells surrounding the park and another 600 wells forecast in the next *5* to 10 years, there is a high risk of surface and/or ground water contamination.

Within the Little Missouri River watershed, current agricultural practices that use herbicides, pesticides and fertilizers are also considered a potential threat to the park's water resources. Herbicides used in the park's exotic plant control program could also have an impact on the water resources. Livestock grazing and certain farming methods depend on Little Missouri River water and have the potential to impact water quality and quantity. Together, energy and agricultural activities, coupled with nonpoint source pollution associated with such activities (e.g. erosion, sedimentation, siltation, hazardous chemical spills), and cumulative effects (e.g. naturally high trace metal concentrations of Little Missouri River drainage) pose a threat to the chemical, physical, and biological integrity of surface and ground water resources in Theodore Roosevelt National Park.

Compromising the status of the park's water resources and the direction of water resources planning, is the paucity of information on surface water features (wetlands and riparian areas), surface and ground water quantity and quality, and aquatic biology. For example, there are approximately 76 surface water quality monitoring stations along the Little Missouri River and its tributaries within and adjacent to Theodore Roosevelt National Park. Most of these stations are historic and currently not in use, with only four stations (two stations within park boundaries and two transboundary stations) presently collecting water quality samples on a regular basis. Additionally, the aquatic invertebrate communities of southwestern North Dakota are virtually unstudied.

Without better water resource information and adequate baseline data, any impacts on water resources will remain undetected and changes will be difficult to document. Determining the status of contaminants on water, sediment, and the biota in the park would serve as a benchmark for future comparisons and would help to identify problem contaminants and/or sites for possible remedial action. At a minimum, waters entering the park should be in compliance with state water quality standards. A comprehensive water quality monitoring program for surface and ground waters is essential to develop adequate baseline information and to determine compliance with water quality standards. An important first step in the development of the water quality monitoring program is the development of a water quality monitoring plan and analysis of existing water quality information (see Project Statement THRO-N-200.001, Appendix C).

Presently, the State of North Dakota is undergoing the triennial review of its water quality standards pursuant to Section 303 of the Clean Water Act. Paying particular attention to antidegradation of water resources, the state is proposing the implementation of new regulations that will establish "Outstanding State Resource Waters" (Sauer 1998). A determination of Outstanding State Resource Water will establish the highest level of protection under state water quality standards to a water body so designated. The park is encouraged to petition the state for this designation for the Little Missouri River. However, instead of working unilaterally for this designation within park boundaries, the park should work cooperatively with other landowners to designate the majority of the Little Missouri River in North Dakota as an Outstanding State Resource Water.

The aquatic biological communities of Theodore Roosevelt National Park do not appear to be species rich. This is probably a result of several factors: naturally high turbidity, shifting sand/gravel river bottoms, highly variable flow regime on permanent rivers, high intermittency of tributaries, and the presence of trace metals in already high concentrations. Perhaps for these reasons, studies of the park's aquatic communities have been limited to a few cursory fish surveys and presence/absence surveys of aquatic/riparian vascular plants; with the invertebrate component completely unstudied. Project Statement THRO-N-200.006 (Appendix C) proposes that the park partner with the State of North Dakota in developing a multimetric index to assess the integrity of the aquatic macroinvertebrate communities in the park. The development of this index will provide needed baseline information on aquatic invertebrate communities, as well as provide a means to assess biological integrity in the water quality monitoring program.

Efforts to measure aquatic biological integrity in North Dakota began in 1993 (North Dakota Department of Health 1996). The first project, in the Red River Valley, was a cooperative venture with the Minnesota Pollution Control Agency, Regions V and VIII of the U.S. Environmental Protection Agency, and the U.S. Geological Survey's National Water Quality Assessment Program. This project focused on the development of a fish-based multimetric index. In 1995, sampling efforts were concentrated along the Sheyenne River for both fish and macroinvertebrate communities. Presently new biological indices are being formulated for the macroinvertebrate community. These macroinvertebrate-based, multimetric indices are the models that could be tested and refined in western North Dakota.

Wetlands and riparian areas are some of the most productive and significant natural resources at Theodore Roosevelt National Park; however, these aquatic systems are not understood nor is it known what species are present. From a management viewpoint, knowledge of aquatic ecosystems and related water resources is basic to managing a park in an and environment where having an adequate and acceptable water supply is always a concern and where wetlands are rare and precious commodities.

Habitat maps for wetland areas, combined with inventories of flora and fauna within those areas, are needed (See Project Statement 1'HRO-N-200.002, Appendix C). Given detailed maps and inventories, resource managers will be able to detect the responses of wetlands and riparian zones to various natural and human-induced disturbances.

Healthy riparian systems can be described as being geologically stable, with streamfiow and sediment discharges that are in dynamic equilibrium with their upland watersheds, and as having wetland and riparian vegetation that has appropriate structural, age, and species diversity. When these attributes are maintained, riparian systems provide forage and cover for wildlife and improve water quality by filtering sediment and recycling nutrients. If, however, any of the essential attributes are missing or degraded, or if the system becomes geologically unstable, widespread erosion may occur that will degrade water quality and cause damage or loss of wetland and riparian habitats. Project Statement THRO-N-200.003 (Appendix C) proposes to assess the functional condition of riparian areas in the park using a recently developed model that assesses "functionality" according to hydrological, vegetational, and stream geomorphological factors.

Wetlands occur in riparian areas along major water courses and are also scattered throughout the park in association with springs and seeps. Many are heavily affected by grazing, either by native ungulates or free-roaming bison. Since these areas provide water for wildlife, much activity is concentrated there, especially where dish tanks are provided. As such, the park is faced with the dilemma of ensuring protection of wetland resources in the face of impacts from overuse by these herds. Project Statement THRO-N-200.008 (Appendix C) addresses this concern through the use of exciosures. However, the park should also consider removal of some of the dish tanks. These tanks are wetland fill and as such, reduce the potential wetland area by concentrating the hydrology. It is current National Park Service policy to restore degraded wetland areas where practicable (see Procedural Manual #77-1, "Wetlands Protection"). If restoration is not practicable, then adverse impacts are to be mitigated. Project Statement THRO-N-200.008 addresses this policy only through mitigation.

No systematic effort has been made to evaluate the expected variations in discharge that springs and seeps may exhibit in response to variations in precipitation on monthly, seasonal, and annual scales. Basic hydrogeologic principles dictate that springs fed by small, shallow bodies of saturated material may be expected to have sharply varying rates of flow, and respond quickly to precipitation events. Springs and seeps whose source aquifers are larger in volume or more remote from the point of discharge will have a more subdued and delayed response. These predictions should be checked by field observations in order to gain a deeper understanding of the nature of spring flows in the park. Project Statement THRO-N-200.009 (Appendix C) provides guidance for the development of a systematic monitoring program, which will yield a valuable data base that, along with climatic data, will enable the park resource managers to reliably estimate spring flow conditions in the park.

Water Rights

It is important for Theodore Roosevelt National Park to legally establish its water rights under state or federal law. The last water rights assessment was completed in 1964, and, given the elapsed time and the varied and multiple land uses surrounding the park, it is unknown to what extent the park's water resources may already be protected by both state appropriative and federally reserved water rights. A water rights evaluation is needed that will identify state appropriative rights certified for use on, or diversion from park lands. Determination of water rights or unrecorded uses, and identification of alternatives to protect or acquire rights, needs to be completed. Without this information, the park is not assured of ample water resources for its long-term sustainability. Project Statement THRO-N200.004 in Appendix C is designed to address this concern.

Oil and Gas Development

Approximately 1,600 oil and gas wells surround the park (Figure 4 in pocket) and about 600 wells are planned over the next 10 years (U.S. Forest Service and Bureau of Land Management 1995). Park resource managers need to be aware of oil and gas operations within a regional context. In many cases, developing cooperative monitoring efforts with other agencies is an effective strategy.

Facilities associated with the oil and gas development include: producing, shut-in, plugged, and saltwater injection wells; petroleum, gas, and saltwater pipelines; active reserve and buried reserve pits; and, storage tanks, as well as an extensive network of roads. Pipelines cross the Little Missouri River, and wells and pipelines are located in river and stream floodplains upstream from park boundaries. A high potential for oil or chemical contamination of the river and aquifers exists from this development. Table 8 summarizes the potential and general effects of oil and gas activities on water resources.

Potential effects of spills on water quality may be significant. Impacts to surface water quality are likely to be short-term and difficult to track, whereas impacts to the ground water resources would be long-term. Pollutants may be retained in surface water for months; however, pollutants in the ground water are commonly retained for decades or centuries. It is for this reason that pollution of ground water resources can be considered a significant, irreversible, and irretrievable loss. The contamination of the aquifers could also result in eventual contamination of surface waters that are in hydraulic contact with the shallow aquifers.

Once drilling and pumping for oil are underway, the potential exists for spills and leaks of drilling fluids, muds, oil, or produced wastes. The drilling fluids and natural ground water encountered in the drilling process are often high in dissolved salt content (especially sodium, calcium, magnesium, and chloride) and sometimes contain heavy metals such as barium, cadmium, chromium, lead, strontium, and zinc (National Park Service 1987a; Irwin et al. 1997).

Table 8. Potential effects of oil and gas activities on water resources.

Activity	Potential Effects
Exploration road and drill pad construction	Increased runoff, erosion, and sediment to streams and impoundments. Impacts to aquatic flora and fauna.
Drilling reserve pit operations	Release of produced brine, drilling mud and additives, and low hydrocarbons to surface and/or shallow ground water. Potential mortality of aquatic flora and fauna.
Blow outs	Release of brine, drilling fluids, and hydrocarbons to surface. Potential surface and ground water contamination effects. Potential mortality of aquatic flora and fauna.
Production salt water disposal	Leakage from collector lines to surface or shallow ground water. Leakage form injection wells to potable water aquifers. Spills would kill vegetation and sterilize soil. Potential for mortality of aquatic flora and fauna.
Abandonment well plugging	Migration of brines through incompetent seals to potable aquifers.
Seepage and/or rupture of pipelines/storage tanks	Release of product to surface. Potential surface and ground water contamination effects. Potential mortality of aquatic flora and fauna.
Accidents from tanker truck spills	Release of product to surface. Potential surface and ground water contamination effects. Potential mortality of aquatic flora and fauna.

Source: Modified from U.S. Forest Service and Bureau of Land Management (1991).

The largest volume of waste associated with oil and gas exploration activities is produced water. Most is saline. The total dissolved solids in produced water ranges from several hundreds parts per million (ppm) to over 150,000 ppm. Seawater, by comparison, is typically 35,000 ppm. Bicarbonates, carbonates, sulfates, sulfides, and oil may also be associated with produced waters and drilling fluids. The potential also exists for spills or leaks of such substances as detergents, fuels, machinery fluids, and toxic chemicals. Trucks transporting oil or produced water pose further spill hazards, and storage tanks or pumping stations sometimes rupture. Herbicides sprayed for brush control along pipelines and other cleared areas can enter streams by way of storm runoff. Finally, fallout of airborne particles (such as dust) can contribute to water pollution problems.

Oil and gas development can cause a population decrease in the aquatic flora and fauna. The most likely effect directly linked with these mortalities is associated with chemical spills and leaks, where chemical contaminants find their way into water courses. There is sufficient field and laboratory evidence that demonstrates both acute and lethal toxicity and long-term sublethal toxicity of oils and petroleum distillates to aquatic organisms (U.S. Environmental Protection Agency 1986). Depending upon the type of petroleum compound, and the flora and fauna involved, oils and petroleum distillates can be extremely toxic to fish. Also, certain petroleum products which appear to have no soluble poisonous substances, become deadly when emulsified by agitation, as would be the case in the often turbulent stream flows of the Little Missouri River. Oily substances are harmful to aquatic life by: 1) adhering to gills and interfering with respiration; 2) coating and destroying algae and other plankton; 3) coating the stream bottom and destroying benthic organisms; and, 4) direct toxic action on aquatic flora and fauna.

Considering the potential adverse impact to park water resources, the park needs a cost-effective, consistent, and cooperatively-based water quality monitoring program of both surface and ground waters. The Water Resources Division of the National Park Service has recently developed draft standard protocols for monitoring contamination from oil and gas fields (VanMouwerik 1998). These protocols should assist in the development of a water quality monitoring program. Based on the risk potential of existing or planned oil and gas operations, a compliance monitoring program is also needed that would include regular tracking inspection records of responsible agencies and photo documentation of oil and gas facilities. Park contacts should be placed on notification lists for development permits for mining operations and oil and gas operations, as well as state public notice lists. Project Statement THRO-N-200.001 (Appendix C) is designed to address these needs.

In addition, the park needs a plan for swift and substantive response to release of hazardous substances such as oil, saltwater, and hazardous chemicals. Project Statement THRO-N-200.005 (Appendix C) addresses this need.

Effects **of Herbicides on Park Water Resources**

Much of the land area adjacent to Theodore Roosevelt National Park supports agricultural activity, which, as currently practiced, necessitates exotic weed control to maintain viability. Leafy spurge is a serious problem within and outside Theodore Roosevelt National Park. Its invasion is disrupting native plant communities and threatening the survival of several rare plant communities. In addition, leafy spurge has no forage value to the large native ungulates in the park, and its presence is therefore reducing the carrying capacity of the area (National Park Service 1994).

Since leafy spurge appears to grow primarily in drainage channels and creek and river bottoms (Anderson et al. 1994), it is critical that careful planning occur before eradication treatment begins. An integrated pest management approach, which includes the use of herbicides, has been proposed for the park (National Park Service, 1994). Proposed herbicides include picloram, glyphosate, 2,4-D, and fosamine ammonium, or combinations thereof. These same chemicals are being used by the agricultural community in the surrounding area.

More than 1.1 billion pounds of pesticides (includes herbicides) are used each year in the United States. National agricultural use of herbicides, insecticides, and fungicides has grown almost fourfold from 1964 to 1993 (U.S. Geological Survey 1997). Although the use of pesticides has resulted in increased crop production and other benefits, concerns about potential adverse effects of pesticides on environmental health have grown steadily. The greatest potential for adverse effects of pesticides, in many respects, is through contamination of the hydrologic system (U.S. Geological Survey 1997).

Water is one of the primary pathways by which pesticides are transported from their application areas to other parts of the environment.

Surface waters are particularly vulnerable to pesticide contamination because runoff from most agricultural areas drains into streams. Pesticides may also enter streams through wastewater discharges, atmospheric deposition, spills, and ground water inflow. In general, herbicides have been detected more frequently than insecticides, consistent with the greater use of herbicides (U.S. Geological Survey 1997).

Seasonal patterns of pesticide occurrence in surface waters vary in different areas of the United States. For the Northern Great Plains, the pattern is probably similar to studies conducted on the illinois River in Illinois where a distinct peak occurs in spring and early summer and lasts for a few days to several months, depending on the timing, number of rain events, and the size of the drainage basin (U.S. Geological Survey 1997). By midsummer, transport of pesticides to surface waters diminishes and riverine concentrations decline.

Under provisions of the Safe Drinking Water Act, the U.S. Environmental Protection Agency has established maximum contaminant levels (MCL) for concentrations of certain chemicals in drinking water. Of the currently used pesticides, only nine have established MCLs. Compliance with the Safe Drinking Water Act is determined by the annual average concentration of a specific contaminant in drinking water, based on quarterly sampling. Drinking water derived from some surface water sources in the central U.S. likely contains concentrations of one or more of these compounds above the MCL for part of the year because of the seasonal pattern. Annual mean concentrations however, rarely exceed the MCL.

Our ability to assess the significance of pesticides in surface waters is limited by several factors. First, water quality criteria have not been established for most pesticides. Second, criteria, when established, are based on tests with individual pesticides and do not account for possible cumulative or synergistic effects. Finally, many pesticides and most transformation products have not been widely monitored in surface waters.

Pesticide contamination of ground water is a national issue because ground water is used for drinking water by about 50 percent of the nation's population (U.S. Geological Survey 1995). Concern about pesticides in ground water is especially acute in agricultural areas, where most pesticides are used, and where over 95 percent of the population relies upon ground water for drinking water. Nationally, however, fewer than two percent of the wells in agricultural areas, sampled by multi-state studies, had concentrations that exceeded MCLs (U.S. Geological Survey 1995). However, MCLs or other water quality criteria have not been established for many pesticides. Secondly, many pesticides have not been widely sampled in ground water.

Pesticides may reach ground water through: seepage of contaminated surface waters into underlying aquifers; transport down abandoned or poorly sealed wells; and, injection through wells used to dispose of agricultural runoff. Pesticides are commonly present in low concentrations in ground water beneath agricultural areas, and only seldom at concentrations that exceed drinking water quality standards. To date, the five multi-state studies on agricultural areas determined the proportions of sampled wells with pesticide detections ranged from four percent (nationwide, rural domestic wells) to 62 percent (corn and soybean areas of the northern midcontinent, post-planting) (U.S. Geological

Survey 1995). Pesticide concentrations were 1 microgram per liter or less in over 95 percent of the wells sampled during these studies.

High concentrations of pesticide contaminants in rivers may lead to contamination of shallow ground waters in agricultural areas. This is of special concern during periods of extensive seepage of river water into underlying alluvial aquifers, particularly following spring applications, when pesticide loads and river flows reach maximum levels (U.S. Geological 1995). Conversely, pesticides in alluvial aquifers may flow into adjoining rivers during periods of low runoff.

Table 9 presents characteristics and known water quality criteria for the herbicides used in the control of leafy spurge in Theodore Roosevelt National Park (National Park Service 1994). Glyphosate dissipates rapidly from the water column as a result of adsorption and possibly biodegradation. Glyphosate is so strongly attracted to soil that little is expected to leave from an applied area. Since glyphosate is so tightly bound to the soil, little is transferred by rain. One estimate showed less than two percent lost to runoff (U.S. Forest Service 1984). However, the herbicide could move when attached to soil particles during erosion runoff. Due to its ionic state in water, glyphosate does not readily volatilize from water or soil.

Glyphosate is practically non-toxic to fish. However, Roundup (commercial/residential) was more toxic to fish than glyphosate. In rainbow trout, for instance, the 96-hour LC5O (concentration that is lethal to 50 percent of test subjects over a 96-hour period) was 8.3 mg/l for Roundup and 38 ppm for glyphosate. An additive used in Roundup is apparently more toxic to fish. For this reason, the formulation for use in aquatic situations (Rodeo) omits this ingredient. There is a very low potential for the compound to build-up in the tissues of aquatic invertebrates.

Picloram is the most persistent of the chlorobenzoic acid herbicides. It is most persistent in soil with moderate persistence in water; however, once it enters the ground water, it is long lived. It is very soluble in water and will not adsorb to sediments nor will it evaporate or hydrolyze appreciably. Picloram is moderately to slightly toxic to fish. Rainbow trout had picloram-related 96-hour LC5O of 19.3 mg/l, while it was 6.3 mg/l in channel catfish (Walker and Keith 1992). With LC5O values ranging from 10 to 68 mg/i, picloram is only slightly toxic to aquatic invertebrates.

2,4-D shows low persistence in soil and is the most persistent in water. Adsorption appears to increase with increasing organic content and decreasing soil pH. Leaching to ground water will likely be a significant process in coarse-grained sandy soils with low organic content or with very basic soils. Percolating water appears to be the principal means of movement for this chemical. Some formulations of 2,4-D are highly toxic to fish while others are less so. For example, the LC5O ranges between 1.0 mg/I to 100 mg/i in cutthroat trout, depending upon the formulation used. Channel catfish had less than 10 percent mortality at 10 mg/i in 48 hours. Green sunfish when exposed to 110 mg/i for 41 hours showed no effect on swimming response. Limited studies indicate a half-life of less than 2 days in fish (National Research Council of Canada 1978).

Fosamine ammonium (Krenite) is the least persistent in soil; however, its persistence in water is unknown. It is rapidly decomposed by soil microorganisms. Though quite soluble in water, fosamine ammonium does not show much leaching with soil depth. Fosamine ammonium has low aquatic toxicity to fish and aquatic invertebrates. The 96-hour LC5O for the fathead minnow was greater than 1,000 mg/I, and the 48-hour LC5O for *Daphnia magma* was 1,524 mg/I.

The park conducted a limited water quality monitoring program for picloram and 2,4-D concentrations from 1993 to 1995. Sample sites included Paddock Creek (stations 027 and 036), Knutson Creek (stations 042 and 069), and Wannagan Creek (stations 064, 068, 070, and 071) (Figure 15). The range in median concentrations for picloram (20 detectable samples) was 0.05 to 9.15 ugfl; for 2,4-D (10 detectable samples) the range was 0.25 to 14.8 ugfl. None of the concentrations was in excess of U.S. drinking water standards (Table 9). However, two sites on Wannagan Creek (stations 064 and 070) had median concentrations for 2,4-D above the 4 ug/l water quality criterion for aquatic life (Table 9).

Table 9. Characteristics and water quality standards of pesticides proposed for use in Theodore Roosevelt National Park. The water quality criteria for aquatic life are from Canada; no similar criteria have been developed in the U.S.

Herbicide	**U.S.** Drinking **Water** Standard **(MCL in** mg/i)	**Persistence in Soil** (Half-life in **days)**	**Persistence in Water** (Half-life in **days)**	**Water Quality Criteria for** Aquatic Life (ug/l)
Glyphosate	0.7	30 to 100	a few days	*65*
Picloram	*0.5*	>100	2 to >40	29~
2,4-D	0.07	<30	lO to>50	4
Fosainine Ammonium	None	7 to 10	Unknown	None

[a] Interim guideline in Canada.
Source: U.S. Environmental Protection Agency 1998b.

Recently, the park began using a new imidazolinone herbicide, imazapic (commercial name, Plateau) on leafy spurge. Currently, little is known about the occurrence, fate, or transport or imidazolinone herbicides in surface or ground waters of the U.S. (U.S. Geological Survey 1998). To date, detections have been at nanogram per liter concentrations (Battaglin et al. 1998). However, several studies indicate that some imidazolinone herbicides may leach beyond the active root zone and enter ground or surface waters. The U.S. Geological Survey and the Dupont Corporation have combined efforts to collect information on three imidazolinone herbicides (does not include imazapic) in water resources of the midwestern United States (U.S. Geological Survey 1998).

The possibility of sublethal effects on aquatic organisms cannot be excluded, but the intermittent application, short duration of exposure, and relatively low concentrations, all suggest that these effects are generally small or insignificant (MacDonald et al. 1991). A detailed study of the effects of glyphosate on a stream in coastal British Columbia, for example, confirmed short-term avoidance and stress by Coho salmon and two species of invertebrates in an oversprayed tributary; long-term effects were deemed negligible (Reynolds Ct al. 1989). A survey was made of over 118,000 records from Canadian surface water quality databases during the period 1971-1988. For the prairie provinces, 63 pesticides from 308 sampling stations were surveyed, and it was revealed that the 10 most frequently detected pesticides included picloram (10th) and 2,4-D (4th) (Wood 1996). Although the guidelines for aquatic life were exceeded on numerous occasions in the prairie region, Canadian guidelines for drinking water quality were not exceeded. Aquatic life guidelines are exceeded more commonly because they are several orders of magnitude lower than those for drinking water (mg/I versus ug/l; see Table 9).

Overall, a picture is emerging in Canada that pesticide concentrations in ground water are low, and generally exceedance of guidelines for health, agriculture, or aquatic life is rare (Wood 1996). Contamination is generally restricted to the zone near the water table. Widespread contamination of aquifers by pesticides appears to be unlikely. Wood and Anthony (1995) studied herbicide residues in 14 shallow prairie aquifers used as drinking water supplies. They used ultra-trace methods that are one to two orders of magnitude below conventional detection limits. Picloram and 2,4-D were among the most frequently detected pesticides, primarily a result of their persistence and mobility in water. Since low detection levels were employed, the detection frequencies were about six times the frequency expected if conventional methods had been used. Detections occurred in 25 percent of samples collected and 40 percent of the aquifers studied. However, the levels detected were extremely low and mostly in the part per trillion range. Detections were also well below any known guidelines.

Most recent research suggests that pesticide concentrations attenuate rapidly to low levels as they move through the soil to the water table. Therefore, serious farm well contamination in most instances likely originates from cleaning equipment near wells and mishandling rather than infiltration to the water table following spray applications (Wood and Anthony 1995). While contamination of ground water sometimes occurs, most contamination is restricted to the unsaturated zone near and above the water table, and concentrations tend to be low. In a recent survey of 1,000 farms in Alberta, there were no detectable herbicide residues (Fitzgerald 1995).

Baseline water quality information is needed so the park can evaluate whether its efforts to control leafy spurge will be more of an environmental cost than benefit. Project Statement THRO-N-200.007 (Appendix C) is designed to address this concern, taking into account the recent research discussed above. Understanding the areal extent and concentration of herbicides after eradication efforts within park boundaries should allow the park to comprehend the potential for contamination of park water resources from transboundary efforts.

MEDIUM PRIORITY ISSUES

Floodplain Hazard Identification

Risks associated with flooding represent a significant natural hazard in Theodore Roosevelt National Park to visitors, staff, and infrastructure. Flash floods in tributaries often result from small intense rainstorms and can happen suddenly and without warning. Flash floods represent considerable hazard at low-water road crossings, campgrounds, and potentially to hikers crossing and hiking along tributary streams. Floods in the Little Missouri itself typically occur as a result of longer rainfall events covering the upper watershed area. High flows in the main river threaten visitors, buildings, and other park facilities located in or along the river corridor. However, Little Missouri flooding on overbank areas presents less hazard to visitors, in general, than flashy tributaries because of the more advanced warning that is generally available with large-scale storms and related flooding.

At Theodore Roosevelt National Park, the pertinent regulatory floodplains to identify and use as the basis for management decisions are: 1) the extreme floodplain for facilities near flashy tributaries; 2) the 100-year floodplain for most activities in the Little Missouri corridor; and, 3) the 500-year floodplain for critical actions located in the river corridor (National Park Service 1993).

Critical actions are those that would create an added disastrous dimension to a flood event. Examples of critical actions applicable to the park include: fuel storage facilities; large sewage treatment facilities; hazardous materials storage; irreplaceable records; museums; storage of archeological artifacts; and, emergency services. At present, the 100-year and 500-year floodplain elevations have been determined for the Little Missouri River in all units of the park, and 100-year floodplain elevations have been determined for Knutson, Paddock and Squaw creeks. These elevations and the subsequent delineation of the floodplain should become part of the park's geographic information system. This will aid in location of new park facilities subject to the Floodplain Management Guidelines.

The following recommendations apply to preparation for high flows on the Little Missouri River:

- Develop and put into action a contingency action plan anytime potential for flooding exists;
- Distribute periodic information leaflets to all park visitors (or include it in key park literature) warning of occasional flood flows and citing historical examples of such events;
- Post signs at campgrounds and other low-lying use areas as a reminder of such conditions;
- Survey floodplain zones in high-use areas such as campgrounds. The Water Resources Division of the National Park Service can provide technical assistance;
- Evaluate the need for, and feasibility of, taking nonstructural and low-cost structural measures to protect vulnerable areas (e.g. campgrounds, wells and pumps, etc.), based on the results of the floodplain surveys. Such measures may include bank protection, low levee upgrading, and/or site elevation increases in flood-prone areas. Each site must be individually evaluated for flood hazard based on its unique set of hydrologic conditions. The assistance of floodplain management specialists from the National Park Service, Water Resources Division should be sought to complete this task;
- Maintain communication with, or monitor broadcasts of, the National Weather Service, and use this early-warning system to set in motion a set of prescribed precautions (as outlined in the contingency plan) to be taken by park personnel;
- Train key park personnel in procedures to be taken in the event of imminent flood-flow conditions in the park.

In addition, the park should use the techniques established by Williams-Sether (1992). WilliamsSether used multiple-regression equations to estimate peak streamfiow frequencies for streams in North Dakota. The peak-flow equations are applicable to natural-flow streams that have drainage areas of less than or equal to 1,000 square miles. These techniques are therefore applicable to the ungaged tributary streams in the park. This exercise would permit better flood magnitude estimation for flash floods within the park, and thus provide park personnel with better flood warning capabilities with regard to ungaged, park streams.

A number of ice jam flood mitigation measures are possible depending on the type, length, thickness, and accessibility of jams and the available equipment, personnel, and budget (White and Key 1996). Structural measures for ice jam control, such as levees, dikes, and flood walls, are not warranted because the risk of loss of life or property is low. Moreover, structural measures would be at odds with the state's wild and scenic designation as well as any national designation.

Nonstructural measures are those that modify vulnerability to flooding or reduce the severity of ice jam-related floods. White and Key (1996) and Wuebben and Gagnon (1995) provide good reviews of nonstructural mitigation measures. If, in the future, ice jam flooding becomes problematic, the park is encouraged to consult with specialists at the U.S. Army Corp of Engineers' Cold Regions Research and Engineering Laboratory in Hanover, New Hampshire (606-646-4292 or *http://www.crreiusace.almy.mil).*

City of Medora Sewage Treatment Plant

The sewage treatment plant for the City of Medora is located adjacent to the Little Missouri River just upstream from the southern boundary of the South Unit. During high rainfall periods the plant's capacity has been exceeded. When this occurs, the plant discharges directly to the Little Missouri River. High fecal coliform *(Escherichia coli)* counts are usually a direct result of the discharge. Also, given recent and anticipated development, the plant may exceed its treatment capacity even more frequently, resulting in additional direct discharges to the river. This is a public health concern for the park, especially in the summer, when river flow is low and visitation is high. The potential for contact with contaminated river water is great for swimmers or waders in the Little Missouri River.

In the past, high fecal coliform counts have been recorded from four monitoring stations along the Little Missouri River. At these stations, fecal coliform was measured a total of 220 times from 1971 to 1994 (Table 6). The North Dakota safe limit for fecal coliform was exceeded 54 times for an exceedance rate of approximately 25 percent (Table 6). However, 63 percent of these exceedances were reported from the Little Missouri River at Medora.

It is not the high concentration of E. *coli,* in itself, that causes concern to public health, but rather it is the harmful pathogens often associated with *E. coli* from fecal contamination. It is difficult to test for many of these pathogens, so *E. coli* is widely used as an indicator of fecal contamination. The State of North Dakota has set a safe limit of 200 colonies/100 ml for water contact in recreational use.

Due to the potential for public health threat, fecal coliform monitoring of the Little Missouri River within the park boundary, downstream of the treatment plant, should be considered as part of the development of a water quality monitoring program (see Project Statement THRO-N-200.001, Appendix C). This program would assist the park in determining if or when Little Missouri River waters within the park should be closed to water contact recreation. It would also provide needed data for National Pollution Discharge Elimination System (NPDES) permit reviews and any compliance actions needed because of permit violations. The park should work closely with the North Dakota Department of Health on this issue.

Overgrazing

Livestock grazing can affect all four components of the aquatic system -- streamside vegetation, stream-channel morphology, shape and quality of the water column, and the structure of the soil portion of the streambank (Platts 1979; U.S. Environmental Protection Agency 1993). Livestock grazing can affect the streamside environment by changing, reducing, or eliminating vegetation bordering the stream. Channel morphology can be changed by sediment accrual, altered channel substrate composition, disrupted pool/riffle relationships, and channel widening. The water column can be altered by increasing water temperature, nutrients, suspended sediment, and bacterial counts, and by altering the timing and volume of water flow. Livestock can trample streambanks, causing banks to slough off, creating false setback banks, and exposing banks to accelerated soil erosion.

Scientific studies of the long-term effects of human disturbances on riverine ecosystems reveal that land-use activities like grazing can have ecological consequences that persist for decades or centuries (Frissell 1993). These activities involve permanent or persistent changes in the watershed, which are directly or indirectly reflected as changes in the riverine ecosystem. Since they cause sustained alterations of habitat structure and biological communities, these activities have been termed press disturbances (Doppelt et al. 1993). Recovery of fish and other forms of riverine-riparian biodiversity and other aspects of flowing water structure from press disturbances most often involves time frames of at least several decades, and a return to healthy conditions may never occur in some cases.

Project Statement THRO-N-200.003 (Appendix C) provides for an assessment of the proper functioning of riparian systems from the standpoint of hydrology, vegetation, and stream geomorphology. Establishing baseline conditions would allow the park to determine the location of and need for any remedial action. Project Statement 1’HRO-N-200.008 (Appendix C) is a remedial action for those springs and seeps being adversely affected by ongoing bison herd grazing.

Internal Landfills

Since ground water provides the main source of drinking water for the park, there should be a plan for monitoring the status of the old landfills. The location of these landfills should be mapped. Ground water monitoring wells should be placed down gradient of the landfills and should be checked periodically for contaminant migration. This monitoring is to determine any potential threat to drinking water supplies. The park should develop a plan for well location and water quality parameters to be monitored.

Cooperation and Partnerships with Other Entities

The park’s well-being is closely intertwined with that of its neighbors. A wide array of land management and land use activities exist on public and private lands upstream of the park’s units. Lands adjacent to the boundaries have been leased for the extraction of coal, oil and gas. Clearing lands for development, oil and gas drilling, and agricultural and residential land activities can impact water quality by causing soil erosion, ground and surface water pollution, and drainage alteration.

Various regulatory issues need to be considered when addressing long-term protection of water resources of the park. Land use planning, zoning regulations, stormwater management guidelines, erosion control for development and roads, and stream-side buffer zone protection all have the potential to protect, preserve, and in some cases improve water resource conditions in the Little Missouri River drainage. The U.S. Forest Service, state and local governments, county planning commissions, and various other entities deal with these issues. There is a need to communicate to these agencies the importance of preserving the integrity of the Little Missouri River and its tributaries and to implement voluntary incentives to reduce the impact of nonpoint source pollution from increased land use conversion and resource extraction activities. It is unlikely, given the economic and political considerations, that additional regulations will be enacted. Voluntary incentives and public education, however, are likely over time to assist in reducing the impact of nonpoint source pollution, if a coordinated effort is made to emphasize the importance of the Little Missouri River as a unique natural resource.

A broader focus on watershed-based management of water resources inherently requires ongoing coordination and cooperation with other agencies and stakeholders in the watershed. Partnerships are a key to effective watershed management. Coordination and cooperation with landowners, local businesses, special interest groups, developers, and government officials involved in water resources is essential to keep the park aware of watershed activities. Coordination and cooperation are also important as mechanisms for representing interests of the park in the complex and, at times, overlapping and seemingly contradictory efforts at water management.

When possible, the park should develop partnerships with other federal, state, and local agencies. An example of this kind of opportunity is the alert to oil spills. The park may want to develop the spill contingency plan (Project Statement THRO-N-200.005, Appendix C) in conjunction with the Bureau of Land Management, U.S. Forest Service, and any appropriate state and local authorities. This partnership and program could be established to aid the park with timely notification of oil spills.

Another example of cooperation and partnership is that addressed in Project Statement THRO-N200.006 (Appendix C) between the park and North Dakota Department of Health. This project statement calls for a pilot study that would test and refine the state's biological monitoring program (a macroinvertebrate-based multimetric index developed in the Red River) in western North Dakota and Theodore Roosevelt National Park.

Public/private partnership opportunities should also be examined. In particular, the park should work closely with oil and gas operators and state and federal inspectors during all exploration, drilling, and production operations. The objective of this program would be to provide an early warning monitoring network of the local water resources for active and abandoned oil and gas operations. This program would: 1) identify the locations of active and abandoned oil and gas operations for inclusion in the baseline land use assessment and mapping projects; 2) document and describe any observed spills, road erosion or other impacts, and immediately report these impacts; 3) verify and monitor proper road construction and disposal of waste material; and 4) develop and implement mitigation projects addressing identified impacts.

Wild and Scenic Proposal

The Little Missouri River is eligible for National Wild and Scenic River designation. The process of determining whether this stream will be designated as Wild and Scenic is in its initial stages. Public comment on this designation was accepted until July 31, 1997 (Federal Register: February 26, 1997, Vol 62, No 38, pp. 8680-8685). The U.S. Forest Service and the National Park Service are evaluating the river for designatibn cooperatively (Ohlrogge 1997). A National Wild and Scenic River designation for the Little Missouri River would be important to the park in providing extra protection for the river, especially with regard to oil and gas exploration and sand and gravel extraction in the Little Missouri River drainage.

Possibility of Sand and Gravel Extraction from the Little Missouri River

Currently, there are sand and gravel mining operations near the Little Missouri River, and additional mining is planned for the riverbed itself (Andrascik 1996). Sand and gravel are used as construction aggregate for roads and highways, pipelines (bedding), septic systems (drain rock in leach fields), and concrete for highways and buildings (Kondolf 1997). In many areas, aggregate is derived primarily from alluvial deposits, either from pits in river floodplains and terraces or by instream mining --removing sand and gravel directly from river beds with heavy equipment.

Instream mining may be carried out by excavating trenches or pits in the riverbed. It may also take the form of gravel bar skimming (or scalping), removing all the material in a gravel bar above an imaginary line sloping upward from the water's edge during the summer. This type of mining directly alters the channel and bed elevation and may involve extensive clearing, diversion of flow, stockpiling of sediment, and excavation of deep pits (Sankecki 1989). As a result, bridge piers and other structures may be undermined, and buried pipeline crossing and water-supply facilities may be exposed. Secondary effects of instream mining include a wider, shallower streambed, leading to increased water temperatures, modification of pool/riffle distribution, alteration of intergravel flow paths, and thus degradation of fish reproductive habitat (Kondolf 1997).

By removing sediment from the channel, instream gravel mining disrupts the pre-existing balance between sediment supply and transporting capacity, typically inducing incision upstream and downstream of the extraction site. Mining-induced incision may propagate upstream for miles on the main river (Scott 1973 and Stevens et al. 1990) and up tributaries (Harvey and Schumm 1987). Gravel pits trap much of the incoming bedload sediment, passing 'hungry' water downstream, which typically erodes the channel bed and banks to regain at least part of its sediment load. Incision of the riverbed typically causes the alluvial aquifer to drain **to** a lower level, resulting in a loss of aquifer storage from 1 to 16 percent, depending on local geology and aquifer geometry (Lake County Planning Department 1992).

In 1995, the U.S. Department of Transportation issued a notice to state transportation agencies indicating that federal funds would no longer be available to repair bridges damaged by gravel mining, a move that may motivate more vigorous enforcement of regulations governing gravel mining in rivers by states.

Comprehensive management of gravel and sand in river systems should be based on a recognition of natural flow of sediment through the drainage network and the nature of impacts (to ecological resources and infrastructure) likely to occur when the continuity of sediment is disrupted. A sediment budget should be developed for present and historical conditions as a fundamental basis for evaluation of these impacts, many of which are cumulative in nature (Kondolf 1997).

The regional context of aggregate resources, market demand, and the environmental impacts of various alternatives must be understood before any site-specific proposal for aggregate extraction can be sensibly reviewed (Kondolf 1997). In general, effects of aggregate mining should be evaluated on a river basin scale, so that the cumulative effects of extraction on the aquatic and riparian resources can be recognized. Sand and gravel operations could greatly impact the Little Missouri River and its ability to be self maintaining. Depending on the gravel pit location, these operations have the potential to negatively impact park water resources as well. The park needs to determine the location of any proposed mine and evaluate its potential impacts on water resources.

Underground Storage Tanks

As of December 1998, the park has four, 550-gallon heating fuel tanks. The one at Cottonwood Campground will be removed in early 1999. Fuel oil tanks were, for the most part, replaced with underground propane tanks. The locations of all underground storage tanks should become part of the park's geographic information system.

Care should be taken to assure that tank removal pits are free from product contamination. All underground storage tank removals should be coordinated with the Underground Storage Tank Program of the North Dakota Department of Health, Division of Waste Management. This program works with underground storage tank owners to ensure that the compliance and leak detection associated with removal are completed in accordance with North Dakota's underground storage tank rules (NDCC 23-20.3INDAC 33-24-8).

Fuel oils are comprised of mixtures of petroleum distillate hydrocarbons (Irwin et al. 1997). The oil may be a distillated fraction of a crude petroleum, a residuum from refinery operations or a blend of these. The most toxic components of fuel oils are the aromatics, such as benzene, toluene, xylene, naphthalene, and others (Irwin et al. 1997). These aromatics are relatively highly soluble in water. Short-term hazards of these water soluble compounds include the potential acute toxicity to aquatic life in the water column. Long-term potential hazards include contamination of ground water.

Petroleum is a complex mixture of thousands of different hydrocarbons and related substances, all of which have different physical and chemical properties. As such, determination of the fate and toxicity of a particular oil is a difficult task. The prediction of environmental impact must take into consideration the unique characteristics of the particular oil spilled as well as the specific spill environment (Irwin et al. 1997).

Historical Uranium Mining

Western North Dakota contains several areas of known radioactive mineral deposits. Investigations conducted from the late 1940s to the late 1970s discovered several large areas of increased radioactivity in Bowman, Slope, Stark, Billings, and Golden Valley counties. Uranium and other radioactive elements were often found associated with beds of lignite.

Beginning in 1956, a few hundred tons of uraniferous lignite were shipped from North Dakota to processing plants. The mills were set up to process uraniferous sandstones and had difficulty processing the low grade ore lignites. In 1962, this problem was rectified by burning the uraniferous lignite in pits at the mine site, often by burning the bed, in place, after the overburden had been removed. The process reportedly took from 30 to 60 days, and diesel fuel and old tires were often mixed with the lignite to assure that it would burn sufficiently. The ash from the mines was then sent to Belfield or Griffith where it was further reduced by burning in kilns.

With respect to surface waters, the National Park Service (1997) found a total of 14 water quality monitoring stations (none within park boundaries) that determined uranium concentrations. However, these stations represented one-time samples from either 1983 (one station) or 1984 (13 stations). Most of these stations were located in tributaries south of the South Unit and had uranium concentrations well below the current drinking water criterion (20 ug/l). Two stations (THRO 0009 and THRO 0015), were located on Government Creek (Figure 15). Station THRO 0009 was the only station with a uranium concentration exceeding the criterion - in this case, the concentration was 200 times the criterion. This retrospective analysis by the National Park Service provides little information of value in an assessment of current water quality conditions; however, the fact that radiological parameters have not been measured on a consistent basis is noteworthy.

Studies have been conducted by the Department of Energy into the locations and potential health risks of radioactive dust that spread from the uraniferous lignite burn sites, both at the mines and the Belfield and Bowman kiln sites. Park staff have expressed concern that the deposition of this radioactive dust may pose a water quality problem within the park. Radiological, water quality monitoring parameters could be included in the water quality monitoring program defmed by Project Statement THRO-N-200.001 (Appendix C).

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APPENDIX A

Wetland Types
in Theodore Roosevelt National Park

Appendix A. Summary of wetland types in Theodore Roosevelt National Park. All information is derived from National Wetland Inventory maps from the U.S. Fish and Wildlife Service. The following National Wetland Inventory maps do not identify any wetlands: Stock Butte; Tepee Buttes; and, Lone Butte. Wetland classification codes (after Cowardin et al. 1979) are explained on the following page.

SUMMARY OF WETLAND TYPES IN THEODORE ROOSEVELT NATIONAL PARK AS DEPICTED BY NATIONAL WETLAND INVENTORY MAPS

USGS QUAD NAME AND PARK SECTION / WETLANDS CLASSIFICATION	SPERATI POINT NORTH	LONG X DIVIDE NORTH	MEDORA SOUTH	GORHAM SW SOUTH	WANNAGAN CREEK EAST SOUTH	FRYBURG NW SOUTH	FRYBURG NE SOUTH	TOTAL [illegible]
$PEMK_x$	0	0	1	0	0	0	0	1
PEMA	2	4	4	0	0	6	4	20
$PEMA_x$	0	0	0	0	0	0	1	1
$PEMA_h$	1	0	0	0	0	0	1	2
PEMB	0	0	0	0	0	1	0	1
PEMC	0	1	1	0	0	2	0	4
$PEMC_h$	0	0	0	1	0	0	0	1
PFOA	0	0	3	0	0	1	0	4
PFOB	1	0	0	0	0	0	0	1
$PADF_h$	0	0	0	0	0	2	0	2
$PABX_s$	0	2	0	0	0	0	0	2
PUSC	0	0	0	0	0	1	0	1
$PUSC_h$	0	0	0	0	0	1	0	1
$PUSK_x$	0	1	0	0	0	0	0	1
$PUBF_x$	0	0	0	0	0	1	0	1
PSSA	0	1	0	0	0	0	0	1
R2USA	13	14	20	0	9	11	0	67
R2USC	18	16	29	0	16	19	0	98
R2UBF	6	0	3	0	3	3	0	15
R4SBA	0	2	1	0	0	8	4	15
R4SBC	0	0	1	0	0	3	0	4
TOTAL	41	41	63	1	28	59	10	243

WETLANDS AND DEEPWATER HABITATS CLASSIFICATION

SYSTEM: R — RIVERINE

SUBSYSTEM: 1 — TIDAL; 2 — LOWER PERENNIAL; 3 — UPPER PERENNIAL; 4 — INTERMITTENT; 5 — *UNKNOWN PERENNIAL*

CLASS	Subclass
RB — ROCK	1 Bedrock 2 Rubble
UB — UNCONSOLIDATED BOTTOM	1 Cobble-Gravel 2 Sand 3 Mud 4 Organic
*SB — STREAMBED	1 Bedrock 2 Rubble 3 Cobble-Gravel 4 Sand 5 Mud 6 Organic 7 Vegetated
AB — AQUATIC BED	1 Algal 2 Aquatic Moss 3 Rooted Vascular 4 Floating Vascular 5 *Unknown Submergent* 6 *Unknown Surface*
RS — ROCKY SHORE	1 Bedrock 2 Rubble
US — UNCONSOLIDATED SHORE	1 Cobble-Gravel 2 Sand 3 Mud 4 Organic 5 Vegetated
**EM — EMERGENT	2 Nonpersistent
OW — *OPEN WATER/ Unknown Bottom*	

*STREAMBED is limited to TIDAL and INTERMITTENT SUBSYSTEMS, and comprises the only CLASS in the INTERMITTENT SUBSYSTEM.

**EMERGENT is limited to TIDAL and LOWER PERENNIAL SUBSYSTEMS.

SYSTEM: P — PALUSTRINE

CLASS	Subclass
RB — ROCK BOTTOM	1 Bedrock 2 Rubble
UB — UNCONSOLIDATED BOTTOM	1 Cobble-Gravel 2 Sand 3 Mud 4 Organic
AB — AQUATIC BED	1 Algal 2 Aquatic Moss 3 Rooted Vascular 4 Floating Vascular 5 *Unknown Submergent* 6 *Unknown Surface*
US — UNCONSOLIDATED SHORE	1 Cobble-Gravel 2 Sand 3 Mud 4 Organic 5 Vegetated
ML — MOSS-LICHEN	1 Moss 2 Lichen
EM — EMERGENT	1 Persistent 2 Nonpersistent
SS — SCRUB-SHRUB	1 Broad-Leaved Deciduous 2 Needle-Leaved Deciduous 3 Broad-Leaved Evergreen 4 Needle-Leaved Evergreen 5 Dead 6 *Deciduous* 7 *Evergreen*
FO — FORESTED	1 Broad-Leaved Deciduous 2 Needle-Leaved Deciduous 3 Broad-Leaved Evergreen 4 Needle-Leaved Evergreen 5 Dead 6 *Deciduous* 7 *Evergreen*
OW — *OPEN WATER/ Unknown Bottom*	

MODIFIERS

In order to more adequately describe wetland and deepwater habitats one or more of the water regime, water chemistry, soil, or special modifiers may be applied at the class or lower level in the hierarchy. The farmed modifier may also be applied to the ecological system.

WATER REGIME

Non-Tidal

A Temporarily Flooded
B Saturated
C Seasonally Flooded
D *Seasonally Flooded/ Well Drained*
E *Seasonally Flooded/ Saturated*
F Semipermanently Flooded
G Intermittently Exposed
H Permanently Flooded
J Intermittently Flooded
K Artificially Flooded
W Intermittently Flooded/Temporary
Y Saturated/Semipermanent/ Seasonal
Z Intermittently Exposed/Permanent
U *Unknown*

Tidal

K *Artificially Flooded*
L Subtidal
M Irregularly Exposed
N Regularly Flooded
P Irregularly Flooded
*S Temporary-Tidal
*R Seasonal-Tidal
*T Semipermanent-Tidal
*V Permanent-Tidal
U Unknown

*These water regimes are only used in tidally influenced, freshwater systems.

WATER CHEMISTRY

Coastal Halinity

1 Hyperhaline
2 Euhaline
3 Mixohaline *(Brackish)*
4 Polyhaline
5 Mesohaline
6 Oligohaline
0 Fresh

Inland Salinity

7 Hypersaline
8 Eusaline
9 Mixosaline
0 Fresh

pH Modifiers for all Fresh Water

a Acid
t Circumneutral
i Alkaline

SOIL

g Organic
n Mineral

SPECIAL MODIFIERS

b *Beaver*
d *Partially Drained/Ditched*
f Farmed
h *Diked/Impounded*
r Artificial Substrate
s Spoil
x Excavated

APPENDIX B

State of North Dakota Water Quality Criteria for Class II Waters

APPENDIX B: State of North Dakota Water Quality Criteria for Class II Waters

Parameter	Aquatic Fish and Wildlife	Warm Water Fishery	Cold Water Fishery	Domestic Water Supply	Irrigation	Livestock Watering	Industrial	Recreation
Temperature (°C)		30						
Conductivity (umhos/cm)					2,500			
pH	6-9	6-9	6-9	6-9	6-9			
Dissolved Oxygen (mg/l)	5	5	6					
TDS (mg/l)				500	1,200	10,000		
Residue (mg/l)				500	1,200	10,000		
Percent Sodium				50				
Sulfate (mg/l)				450	750			450
Chloride (mg/l)				250	350			
Ammonia-N (unionized)(mg/l)	0.02	0.02	0.02					
Nitrate-N (mg/l)	1.0	1.0		10				1.0
Phosphate-P (mg/l)	0.1	0.1						0.1
Arsenic (ug/l)				50	100	200		
Barium (ug/l)				1,000				
Boron (ug/l)					750	5,000		
Chromium (ug/l)				50				
Copper (ug/l)				100	100	100		50
Cyanide (ug/l)				5				
Lead (ug/l)				50	10,000	100		
Mercury (ug/l)				2	10			
Selenium (ug/l)				10	20	50		
Zinc (ug/l)				5,000	2,000	2,000		1,000
Radium-226 & 228 (pCi/l)				5				
PCBs (ug/l)				0.15				
Fecal Coliform (# colonies/100 ml)					1,000			200
Phenols (ug/l)				10				

Source: North Dakota Department of Health and Consolidated Laboratories (1991).

APPENDIX C

Project Statements

Project statements are standard National Park Service programming documents that describe a problem or issue, discuss actions to deal with it, and identify the additional staff and/or funds needed to carry out the proposed actions. Project statements can be included in the resources management plan for a park. They are planning and programming documents used to compete with other projects and parks for funds and staff.

Nine project statements have been developed that represent current water resources actions needed at Theodore Roosevelt National Park. The project statements are listed below in order of current priority. Priorities will change as tasks are accomplished, more is learned, and decisions are made internally and externally affecting the relative urgency of various issues. No priority numbers have been assigned to individual project statements. These priorities will be assigned when the project statements are 'uploaded' to the Resources Management Plan.

THRO-N-200.001:

THRO-N-200.002:

THRO-N-200.003:

THRO-N-200.004:

THRO-N-200.005:

THRO-N-200.006:

THRO-N-200.007:

THRO-N-200.008:

THRO-N-200.009:

DEVELOP WATER QUALITY MONITORING PROGRAM

CONDUCT WETLANDS AND RIPARIAN ZONE iNVENTORY AND ASSESSMENT

CONDUCT PARKW1DE STREAM / RIPARIAN FUNCTIONAL CONDITION

WATER RIGHTS EVALUATION

PREPARE HAZARDOUS SUBSTANCE AND SPILL CONTiNGENCY PLAN

ASSESSMENT OF AQUATIC BIOLOGICAL INTEGRITY

HERBICIDE ASSESSMENT

STREAM / SEEP / SPRING EXCLOSURE STUDY

MONITOR WATER RESOURCES - SPRINGS AND SEEPS (CYCLIC)

Project Statment
THRO-N-200.001

Last Update: *09/15/98* Priority: 0000
Initial Proposal: 1998 Page Number: 0001

Title: DEVELOP WATER QUALITY MONITORING PROGRAM
Funding Status: Funded: 0.00 Unfunded: 35.00

Servicewide Issues: Nil (WATER QUAL-EXT)

N12 (WATER FLOW)

Cultural Resource Type:
N-RMAP Program Codes: Q00 (Water Resources Management)
QOl (Water Resources Management)

10-238 Package Number:

Problem Statement

Theodore Roosevelt National Memorial Park was established in 1947 as a memorial to honor its namesake. In 1978, Congress expanded this legislation by establishing Theodore Roosevelt National Park and the Theodore Roosevelt Wilderness. Lying in the Little Missouri Badlands of western North Dakota, this 70,446 acre, three-unit park is managed to protect and interpret, among other things, the Badlands ecosystem surrounding the Little Missouri River.

The major surface water resource in park is the Little Missouri River, which has its headwaters located in northeastern Wyoming. The Little Missouri River extends 225 miles northeast where it terminates upon entering the Garrison Reservoir. The park is located midway within the watershed. The river bisects the park's designated wilderness, flowing through nine miles of the South Unit and 14 miles of the North Unit. The river forms approximately one mile of the eastern boundary of the Elkhom Unit. The river is wild, free flowing, and is designated as a State Scenic River. It is currently being studied for eligibility as a National Wild and Scenic River. The State of North Dakota classifies the Little Missouri River as Class 2 (Aquatic Fish and Wildlife, Warm Water Fisheries, and Recreation). The creeks in tributary watersheds of the park are mostly intermittent.

Water Resource Threats

Theodore Roosevelt National Park lies in the heart of the Williston Basin, a very successful oil and gas development area. Numerous oil fields surround all units of the park containing active, shut-in, plugged, and saltwater injection wells; petroleum, gas, and saltwater pipelines; active and buried reserve pits; and, storage tanks. Pipelines cross the Little Missouri River, and wells and pipelines are located in river and tributary floodplains upstream from the park. Such developments, and their associated infrastructures, create a potential for oil and chemical contamination. Presently, 1,500 wells surround the park, and 630 new wells are forecast in next *5* to 10 years. Development in the watershed has the potential to seriously impair water quality, and reduce surface and ground water quantity, and negatively affect biological resources in the park.

Ongoing agricultural practices adjacent to park units are also a potential threat to park water resources. Herbicides, pesticides, and fertilizers are commonly used and are possible sources of contaminants of both surface and ground water. Herbicide use by the park (primarily picloram for leafy spurge control) could also have an impact on the park water resources. Livestock grazing and certain farming methods depend on Little Missouri River water and are potential impacts on water quality and quantity. Agricultural practices and petroleum exploration and extraction exacerbate naturally high concentrations of arsenic, chromium, copper, lead, and zinc. Together, energy and agricultural activities, coupled with nonpoint source pollution associated with such activities (e.g. erosion, sedimentation, and siltation), and cumulative effects from increases in trace metal concentrations pose a serious and imminent threat to surface and ground water resource integrity in the park.

Adequacy of Current Information

Lack of information on surface water features (springs and seeps), surface and groundwater quantity and quality, and aquatic biology compromises the status of the park's water resources and the direction of water resources planning. For example, there are approximately 76 surface water quality monitoring stations along the Little Missouri River and its tributaries within and adjacent to Theodore Roosevelt National Park (National Park Service 1997). Most of these stations are historic and currently not in use. Presently, there are only four stations (two stations within park boundaries and two transboundary stations) where water quality samples are collected on a regular basis, even though, relatively recent monitoring data indicates the risk potential from energy and agricultural development and practices. Furthermore, between 1985 and 1996, 11 of the 15 water quality monitoring stations in the North and Elkhom Ranch units and 31 of 61 stations in the South Unit exceeded freshwater aquatic life, drinking water and/or bathing water quality standards (National Park Service 1997).

Without timely and comprehensive water quality information or adequate baseline data, impacts on water resources will remain undetected and changes will be difficult to document. Determining the status of contaminants on water, sediment, and biota of the park would serve as a benchmark for future comparisons and would help to identify problem contaminants and/or sites for possible remedial action. At a minimum, waters entering the park should be in compliance with state water quality standards. A comprehensive water quality monitoring program for surface and subsurface waters is essential to develop adequate baseline information and to determine compliance with water quality standards. This monitoring program should satisfy the following water resource management objectives recently formulated by Theodore Roosevelt National Park:

> Manage waters of the park and water dependent environments in a manner designed to maintain the highest degree of biological diversity and ecosystem integrity;
>
> Acquire sufficient knowledge about water quality to effectively participate in state and local water management planning;

Seek the highest level of protection under state water quality standards appropriate for the park; and,

Acquire appropriate baseline information to adequately understand and manage water resources and meet National Park Service inventory and monitoring requirements.

Description of Recommended Project or Activity

The immediate objective for the park is to establish the foundation for future water quality monitoring by designing and initiating a sustainable, long-term program for monitoring water quality. During the first year of the project, a water quality monitoring plan will be developed and implemented by a professional(s) competent in the fields of chemical and biological monitoring techniques and methods. This plan will initially develop monitoring objectives. Identifying the objectives and type of monitoring has implications for the type, intensity, and scale of measurements. Additionally, this monitoring plan will discuss management activities, potential monitoring parameters, frequency and cost of monitoring, statistical considerations, number, location and access to monitoring sites, quality assurance/control, data management, the needs for specific studies and the availability of existing data.

An important step in the development of the water quality monitoring plan, is the summarization and interpretation of existing water quality data. Fortunately, available water quality data from monitoring stations both in and adjacent to the park have been summarized (National Park Service 1997). However, this information should be interpreted and reviewed by a water quality specialist, who will determine whether park water resources are in compliance with state water quality standards. Basic data observation techniques (primarily graphical) and statistical analyses will be performed, and their interpretation will form the basis for a water quality monitoring program sufficient to protect the ecological integrity of the park.

Other aspects of this water quality monitoring plan include:

A design which will establish both a physiochemical and biological baseline for the park's water resources. The plan will develop and/or recommend potential rapid biological assessment techniques for implementation in the water quality monitoring program;

Develop bacteriological monitoring scheme;

Review and citation of the literature necessary to support the plan's rationale and/or recommendations;

Determination of the appropriate mix of regular fixed station monitoring versus the need for events-based monitoring;

At a minimum, all the water quality concerns potentially affecting the park, including radiological;

Location and identification of high risk oil and gas installations that are immediate threats to park water resources. Based upon this identification, the monitoring plan will include a program for compliance monitoring of the high risk facilities, i.e., a way to track high risk oil and gas operations via inspection records of responsible agencies and photo documentation by park officials of these facilities on a regular basis;

A method for tracking State Department of Transportation records for corrosion protection and pressure testing of oil and gas pipelines that may affect park water resources;

Incorporation of all data into the park's geographic information system for tracking and management purposes; and,

Provision of alternatives to accomplish the objectives of the water quality monitoring program (including envisioned cooperative monitoring efforts). The plan should be coordinated with the North Dakota Department of Health, U.S. Forest Service, and the U.S. Geological Survey to optimize a comprehensive monitoring approach.

In the second year, as part of the evaluative process for the monitoring program, some pilot sampling and analysis study will be conducted in order to identify existing conditions, evaluate proposed methodologies for sustainability (cost-effectiveness), evaluate logistical constraints, evaluate procedures for data management and protocols for data evaluation, and design specific criteria that would activate intensive studies of water quality threats. Revisions to the monitoring program would be based upon the results of this pilot study.

Literature Cited

National Park Service. 1997. Baseline Water Quality Data Inventory and Analysis. Water Resources Division and Theodore Roosevelt national Park, Technical Report: NPS/NRWRD/NRTR 97-11. National Park Service, Fort Collins, CO.

BUDGET AND **FFEs**				
FUNDED				
Source	Activity	Fund Type	Budget ($l000s)	FTEs
			0.00	0.00
		Total:	**0.00**	**0.00**
UNFUNDED				
	Activity	Fund Type	Budget ($l000s)	FTEs
Year 1:	MON	One-time	15.00	0.00
Year 2:	MON	One-time	20.00	0.00
		Total:	**35.00**	**0.00**

(Optional) Alternative Actions/Solutions and Impacts
(No information provided)

Compliance codes: EXCL (CATEGORICAL EXCLUSION) Explanation: 516 DM2 APP. 2, 1.6

Project Statment
THRO-N-200.002

Last Update:	09/15/98	Priority: 0000
Initial Proposal:	1998	Page Number: 0001

Title: CONDUCT WETLANDS AND RIPARIAN ZONE INVENTORY AND ASSESSMENT

Funding Status: Funded: 0.00 Unfunded: 45.00

Servicewide Issues: N20 (BASELINE DATA)
N24 (OTHER - NATURAL)

Cultural Resource Type:
N-RMAP Program Codes: Q00 (Water Resources Management)
QOi (Water Resources Management)

10-238 Package Number:

Problem Statement

Background

Theodore Roosevelt National Memorial Park was established in 1947 to honor the life of Theodore Roosevelt. In 1978, Congress expanded this legislation to established Theodore Roosevelt National Park and the Theodore Roosevelt Wilderness. Lying in the Little Missouri Badlands of western North Dakota, this 70,446 acre, three-unit park is managed to protect and interpret, among other things, the Badlands ecosystem surrounding the Little Missouri River.

The major surface water resource in the park is the Little Missouri River, which has headwaters located in northeastern Wyoming. The Little Missouri River extends for 225 miles northeast where it terminates upon entering the Garrison Reservoir. The park is located midway within the watershed. The river bisects the park's designated wilderness and flows through nine miles of the park's South Unit and 14 miles of its North Unit. The river forms approximately one mile of the eastern boundary of the park's third unit, Elkhorn. The river is wild, free flowing, and is designated as a State Scenic River. It is also being studied for National Wild and Scenic River designation. The State of North Dakota classifies the Little Missouri River as Class 2 (Aquatic Fish and Wildlife, Warm Water Fisheries, and Recreation). The creeks in tributary watersheds of the park are mostly intermittent.

The U.S. Fish and Wildlife Service has conducted a map-based inventory of wetlands in and around the park (maps were completed in 1996 based on 1983 photography). While useful, these existing National Wetland Inventory maps are inadequate to meet park management needs or address National Park Service regulatory policies. There is limited "ground truthing" for such maps and small streams, seeps, springs, and their associated riparian-wetland sites may be overlooked at such a scale.

Based on the wetland categories defined by Cowardin et al. (1979) for the U.S. Fish and Wildlife Service National Wetland Inventory, Theodore Roosevelt National Park contains palustrine and riverine wetlands. Riverine wetlands, particularly along the Little Missouri River, are popular recreation areas for visitors to the park. Many of these wetlands are also adjacent to roads and trails. Palustrmne wetlands are scattered throughout the park in association with springs and seeps and are heavily affected by grazing, either by native ungulates or free-roaming “domestic” bison.

Both riverine and palustrine wetlands fall within the broader habitat category of a riparian zone. Generally, a riparian zone is a three-dimensional region of direct interaction between terrestrial and aquatic ecosystems. Functional boundaries of riparian zones extend outward to the limits of flooding and upward into the canopy of streamside or spring-side vegetation (Gregory et al. 1991). A functional view recognizes that boundaries and components of riparian zones are dynamic. Individual riparian zones are usually described by emphasizing the specific components. Dimensions of the area of influence for any specific ecological process, such as plant community succession, sedimentation, or flooding, are determined by spatial patterns of the zone and changes which occur naturally during the ecological processes within the zone (Gregory et al. 1991).

Wetland and riparian areas are some of the most productive and significant natural resources at Theodore Roosevelt National Park. However, the park’s aquatic systems are not understood nor have the present species been identified. From a management viewpoint, knowledge of aquatic ecosystems and related water resources is basic to managing a park in an arid environment where water quality and quantity is always a concern and where wetlands are rare and precious commodities.

Threats to Wetland and Riparian Resources

Present and expected development in the Williston Basin has the potential to seriously impair riparian and wetland resources in the park. Extensive oil and gas development, such as wells, storage tanks, pipelines (both saltwater and oil/gas), active and buried reserve pits, as well as major transportation corridors, surround and in some instances cross the park. Such developments, and their associated infrastructures, create a potential for oil and chemical contamination. With approximately 1,500 wells surrounding the park and another 630 wells forecast in the next 5 to 10 years, there is a high risk of surface and/or ground water contamination.

Within the Little Missouri River watershed, current agricultural practices which employ chemical herbicides, pesticides and fertilizers are also considered a potential threat to the park’s nparian and wetland resources. Livestock grazing and certain farming methods depend on Little Missouri River water and have the potential to impact water quality and quantity. Energy and agricultural activities, and the resulting nonpoint source pollution, pose a threat to riparian and wetland resource integrity. Erosion, sedimentation, siltation and increases in trace metal concentrations are all possible consequences of these influences.

An additional wetland resource concern is the use of these areas by the park’s roving herds of bison, wild horses, and elk. The wetland areas provide a major source of water for wildlife, which naturally concentrates there. As such, the park is faced with the dilemma of ensuring protection of wetland resources from overuse use by these herds.

The threat to water quality places wetland resources and their associated ecosystems at risk of contamination and decimation from overuse. Compromising an assessment of this threat and the direction of water resources planning, is the lack of information on wetland and riparian systems within the park. Without proper inventory and assessment of these resources, it is impossible to ascertain and identify how water resources are being affected and where limited means should be concentrated to best preserve and manage these critical elements of the park.

Problem

Theodore Roosevelt National Park suffers from a critical lack of information on its wetland and riparian systems. The park needs baseline information in order to develop an appropriate program to protect its wetlands and riparian areas, and to develop interpretive information and environmental education activities for visitors. This information is necessary for education about and preservation and maintenance of critical habitat that directly supports biota relying on these resources.

Maps of wetland and aquatic areas, combined with inventories of flora and fauna within those areas are needed for the park. Given detailed maps and inventories, resource managers will be able to detect the responses of wetlands and riparian zones to various natural and human-induced disturbances. A mapping and inventory effort is necessary to address the following water resource management objectives, recently developed by the park:

> Acquire appropriate baseline information to adequately understand and manage water resources and meet National Park Service inventory and monitoring requirements.
>
> Map wetland and riparian areas, and monitor and manage these resources in a manner that will maximize their biological integrity and enhance critical habitat for fish and wildlife and the park’s biodiversity.

This mapping and inventory effort will provide the basis for developing monitoring plans to track natural processes and changes. Coupling the wetland and riparian zone inventory with aquatic surveys, water quality monitoring, and vegetation and wildlife surveys will provide many of the data sets necessary for managers to make well-informed resource protection decisions.

Description of Recommended Project or Activity

Conduct a systematic search of the park for wetlands. Identify all known springs, seeps, perennial stream reaches and riparian areas using National Wetland Inventory topographic maps, aerial photographs, reports from local residents, park visitors, and park staff. Accurately locate springs using a global positioning system device and other appropriate mapping techniques. Map all wetland locations, and store information about the location and characteristics of these wetlands in the park’s geographic information system. Previously unidentified water resources should be located. One method uses aerial photographs to classify the vegetative characteristics of known springs and seeps and applies those characteristics to discover unknown water resources. Ideally, this task should not be limited to wetlands, but done in conjunction with a park-wide vegetation or cover-type mapping exercise. It is recommended that the Cowardin et al. (1979) wetlands classification be adopted. This will maintain consistency with the Department of Interior standard, as well as provide the opportunity for conducting change analysis with the existing (albeit small scale, 1:24,000) National Wetland Inventory maps. In addition, there is now a riparian classification system in place for the western United States (U.S. Fish and Wildlife Service 1997).

Upon completion of the wetland and riparian maps, all riparian and wetland resources will be ground truthed. For this effort, riparian and wetland resources will be classified; major plant types and communities recorded; plant and animal species lists established; flow measurements taken, where applicable; and, general characteristics and management concerns noted. This broad, qualitative survey should be followed by more intensive, quantitative field efforts at selected sites for each wetland type. Site selection must insure that a representative diversity of areas are studied (i.e., broad versus narrow wetlands, proximity to permanent upland sampling or previous study sites, and other criteria). Intensive field studies should include establishment of quantitative vegetation plots or transects to evaluate species composition and community structure, small mammal and herpetile trapping, and the study of relationships between soil type, water table levels, and water quality (see Table 1). Special emphasis should be placed on identifying populations and critical habitat for rare or sensitive species. The intensive field effort should be conducted to encompass all seasonal conditions. Where possible, photographic record should be made for each site visited in the field.

Table 1. Potential water resource inventory parameters.

p	
Springs and Perennial Stream Reaches	
Discharge	Riparian vegetation species list
Conductivity and temperature	Thickness of alluvium
Geological setting	Aquatic biota
Length of surface stream	Developments
Wetted area	Observed impacts (i.e., trampling)
Areal extend of riparian vegetation	
Seeps	
Wetted area	Thickness of alluvium
Areal extent of riparian vegetation	Depth to ground water
Riparian vegetation species list	Aquatic biota
Presence of pools	Developments
Riparian Areas	
Areal extent of riparian vegetation	Dead or dying vegetation
Riparian vegetation species list	Presence of stumps
Thickness of alluvium	Stream channel transects
Depth to ground water	

Source: modified from Mott (1997).

The final report should include maps of the park with wetland types identified. Areal statistics of each wetland type within watersheds and subwatersheds should be included. A written description for each wetland type and study area, and identification of species composition and ecological dynamics of the system will be particularly useful to resource managers and interpretive staffs.

A specimen archive would be provided to the park for their reference collection and for interpretation and environmental education purposes. This would include a series of photographs and collections of preserved or dried specimens for at least the principal and/or indicator species.

Literature Cited

Cowardin L., V. Carter, F. Golet, and E. LaRoe. 1979. Classification of wetlands and deepwater habitats of the United States. U.S. Fish and Wildlife Service Biological Services Program, FWS/OBS-79/3 1. Washington, D.C.

Gregory, S., F. Swanson, W. McKee, and K. Cummins. 1991. An ecosystem perspective of riparian zones: Focus on links between land and water. Bioscience *41:540-551*.

Mott, D. 1997. Saguaro National Park water resources scoping report. Tech. Rpt. NPS/NRWRD/NRTR-97/95. U.S. Department of Interior, National Park Service, Water Resources Division, Fort Collins, CO.

U.S. Fish and Wildlife Service. 1997. A system for mapping riparian areas in the western United States. U.S. Fish and Wildlife Service, Denver, CO.

BUDGET AND FTEs				
FUNDED				
Source	Activity	Fund Type	Budget ($l000s)	FTEs
Year 1: PKBASE-NR	RES	One-time	5.00	0.40
		Total:	**5.00**	**0.40***
		*work conducted by GIS specialist for park		
UNFUNDED				
Source	Activity	Fund Type	Budget ($l000s)	FTEs
Year 1: WRD	RES	One-time	20.00	0.00
Year 2: WRD	RES	One-time	25.00	0.00
		Total:	**45.00**	**0.00**

(Optional) Alternative Actions/Solutions and Impacts
(No information provided)

Compliance codes : EXCL (CATEGORICAL EXCLUSION)
Explanation: 516 DM2 APP. 2, 1.6

Project Statement
THRO-N-200.003

Last Update:	09/15/98	Priority: 0000
Initial Proposal:	0 1/15/98	Page Number: 0001

Title:	CONDUCT PARKWIDE STREAM/RIPARIAN FUNCTIONAL CONDITION
Funding Status:	Funded: 0.00 Unfunded: 45.00
Servicewide Issues:	Ni 1 (WATER QUALITY) N16 (NEAR-PARK DEVELOPMENT)
Cultural Resource Type:	
N-RMAP Program Codes:	Q00 (Water Resources Management) QOl (Water Resources Management)
10-238 Package Number:	

Problem Statement

Given the enclosed nature of Theodore Roosevelt National Park and the free-ranging bison herds and other wildlife that roam within the park, it is vitally important that management include objectives to insure that this northern prairie ecosystem is managed to sustain viable and diverse populations of native plant and animal species, and to protect habitats that support or could support threatened and endangered species. The maintenance of healthy riparian systems is essential in obtaining and sustaining biologically diverse prairie ecosystems. Healthy riparian systems are geologically stable, with streamfiow and sediment discharges in dynamic equilibrium with their upland watersheds. The systems' wetland and riparian vegetation has appropriate structural, age, and species diversity. When these attributes are maintained, riparian systems provide forage and cover for wildlife or domestic livestock and improve water quality by filtering sediment and recycling nutrients. If, however, any of the essential attributes are missing or degraded, or if the system becomes geologically unstable, widespread erosion may occur that will degrade water quality and cause damage or loss of wetland and riparian habitats.

A riparian-wetland assessment tool, The Process for Assessing Proper Functioning Condition, (Bureau of Land Management 1993) can be used to evaluate riparian systems. Originally developed by the Bureau of Land Management, the riparian assessment method is now being applied throughout the western United States by the U.S. Forest Service and the Natural Resources Conservation Service. This technique uses an interdisciplinary team to assess riparian area "functionality" according to 17 hydrological, vegetational, and stream geomorphological factors (e.g., erosion, deposition, channel geometry). It provides an initial screening that can separate areas that are functioning well from those in need of more intensive evaluation or management actions. In this way, money and effort can be targeted toward the higher priority issues.

The “functioning condition” of a riparian area refers to the stability of the physical system, which is dictated by the interaction of geology, soil, water, and vegetation. A healthy or stable stream/riparian area is in dynamic equilibrium with its streamflow forces and channel processes. In a healthy system, the channel adjusts in slope and form to handle larger runoff events with limited perturbation of the channel and associated riparian-wetland plant communities.

Evaluation of functioning condition is not simply an assessment of the ecological status or serial stage of the vegetation community. Rather, evaluation is based upon the concept that the basic elements of physical habitat must first be in place and functioning properly before management of such things as potential natural vegetation communities can occur. During the scoping process, Water Resources Division personnel noted that many segments of the park’s streams appear to be functioning improperly relative to their vegetative, soil and geological attributes, and that there is evidence of channel incision and headcutting processes that threaten to eliminate or greatly reduce the quantity and quality of the riparian resources. To provide appropriate recommendations for management of the park’s streams and riparian areas, a two-year project is required that will:
1) assess riparian functionality; and, 2) investigate the local geomorphology to fully identify the extent to which channel incision threatens park resources, and if artificial channel stabilization will ultimately be required.

Description of the Recommended Project

The basic goals of this project are to: 1) use the Process for Proper Functioning Condition (Bureau of Land Management 1993) to classify park streams as “proper functioning,” “functional-at-risk,” or “nonfunctional”; 2) evaluate and describe geomorphic processes that are responsible for initiating channel incision in the watersheds of Theodore Roosevelt National Park; and, 3) determine if sufficient resistant geologic controls underlying the park are sufficient to prevent channel incision from migrating headward through riparian resources, which are currently stable and unimpacted by adjustments in the base levels of their channels. These goals can be met by implementing a coordinated review of existing literature and tactical field investigations.

Riparian Functionality Assessment

In accordance with the Bureau of Land Management’s protocols for assessing riparian functionality, an interdisciplinary team with expertise in hydrology, soil science, range science, geology, and riparian vegetation will evaluate the capability and potential of park streams by using existing literature and field examinations to obtain information including:

- identification and description of relic areas;
- review of historical photos, survey notes, and other documents that indicate historic condition;
- review of floral and faunal species lists;
- determination of species habitat needs related to species that are or were present;
- examination of soils to determine if they were saturated at one time and are now well drained;
- estimation of frequency and duration of flooding on floodplains and terraces;
- identification of current vegetation and determination of that specie’s historical occurrence in the area;

- determination of the entire watershed's general condition and identification of its major landforms; and,
- identification of limiting factors, both human-induced and natural, and determination of needed remedial actions.

Based on the evaluation of the above factors, the team will classify park riparian areas into one of three categories (proper functioning condition, functional-at-risk, or nonfunctional) as defined by the Bureau of Land Management (1993).

Proper Functioning Condition

Stream/riparian areas are functioning properly when adequate vegetation, landform, or large woody debris are present to:

- dissipate stream energy associated with high water flows, thereby reducing erosion and improving water quality;
- filter sediment, capture bedload, and aid floodplain development;
- improve floodwater retention and ground water recharge;
- develop root masses that stabilize stream banks against cutting action;
- develop diverse ponding and channel characteristics to provide habitat and the water depths, durations, temperature regimes, and substrates necessary for fish production, waterfowl breeding, and other uses; and,
- support greater biodiversity.

Functional-at-Risk

Stream/riparian areas are currently in functional condition, but an existing soil, water, vegetation, or related attribute makes them susceptible to degradation. For example, a stream reach may exhibit attributes of a properly functioning system, but may be poised to suffer severe erosion during a large storm due to likely migration of a headcut or increased runoff associated with the disturbance in the watershed caused by the storm.

Nonfunctional

Stream/riparian areas that clearly are not providing adequate vegetation, landform, or large woody debris to dissipate stream energy associated with high flows, and thus are not reducing erosion, improving water quality, or providing forage and cover for wildlife and livestock. The absence of certain physical attributes, such as a floodplain where one should exist, is an indication of nonuIinctioning conditions.

The product of this phase of the project will be a report containing a compendium of the standard checklist for each nparian area evaluated by the team and a brief summary describing the teams conclusions regarding the overall condition of the park's riparian areas.

Assessment of Geomorphology and Incision Processes

The initial work for this phase of the project will be a compilation of the existing relevant literature on incision processes and geology. Increases in channel width due to incision-related erosion have been documented for streams in at least seven states of the United States and one Canadian province (Shields et al. *1995).* The primary objective for this phase of the project is to search for literature specifically pertaining to western North Dakota watersheds that document channel incision, its causes, and approximate rates of advancement of the process.

The~ second phase of the project will involve field evaluation of the existing geomorphologic status of all streams and riparian areas within the park. This evaluation will specifically focus on the locations of geologic controls that can potentially arrest the process of incision in park streams. The primary objectives for this phase of the project will be to: 1) confirm the presence of resistant geologic formations; 2) evaluate their potential to prevent significant incision and headcutting in park streams; and, 3) identify sites where remedial measures might prevent these incision processes from advancing into high quality stream/riparian systems.

Literature Cited

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Shields, Jr., F., S. Knight, and C. Cooper. *1995.* Rehabilitation of watersheds with incising channels. Water Res. Bul. 3 1(6).

BUDGET AND FTEs					
FUNDED					
	Source	Activity	Fund Type	Budget ($l000s)	FTEs
Total:	**0.00**	**0.00**			
UNFUNDED					
		Activity	Fund Type	Buget ($1000s)	FTEs
Year 1 :		MON	One-time	20.00	0.50
Year 2 :		MON	One-time	25.00	0.50
			Total:	**45.00**	**1.00**

(Optional) Alternative Actions/Solutions and Impacts
(No information provided)

Compliance codes : EXCL (CATEGORICAL EXCLUSION)

Explanation: 516 DM2 APP. 2, 1.6

Project Statement
THRO-N-200.004

Last Update:	09/15/98	Priority: 0000
Initial Proposal:	1998	Page Number: 0001

Title:	WATER RIGHTS EVALUATION
Funding Status:	Funded: 0.00 Unfunded: 10.00
Servicewide Issues:	N20 (BASELiNE DATA)
	N12 (WATER FLOW)
Cultural Resource Type:	
N-RMAP Program Codes:	Q00 (Water Resources Management)
	QOl (Water Resources Management)
10-238 Package Number:	

Problem Statement

State water rights in North Dakota are based on the Doctrine of Prior Appropriation. Under this Doctrine, the party who first utilizes water for a beneficial use has a prior right to use, against all other appropriators, i.e. “first in time, first in right.” The water must be put to beneficial use as defined by the state, which generally includes irrigation; domestic, stock watering; municipal, commercial, and industrial; mining; recreation; fish and wildlife; and, other uses. An appropriative water right is a property right. Under state law it can be bought or sold, and its place of use, purpose, and point of diversion may be changed without loss of priority, provided there is no injury to the water rights of others. Generally, if the water is not used for a period of consecutive years, it may be lost through action by the state (forfeiture) or an intent by the right holder (abandonment).

In North Dakota, both surface and ground waters are subject to appropriation. For domestic, livestock, fish, wildlife, and recreational uses the application of water to a beneficial use is all that is required to establish a right. However, an application may be submitted to the state in order to establish a priority and to change the point of diversion, place, and manner of use. Generally, a diversion, or some means of controlling the water, is required. For use of water for municipal, industrial, mining, or irrigation purposes, a permit must be obtained from the State Engineer.

Federally reserved water rights apply directly to land placed in reserve by the Federal Government. When the Federal Government reserves land for a particular purpose, it also reserves, by implication, enough water, unappropriated at the time of the reservation, as necessary to accomplish the purposes for which Congress or the President authorized the land to be reserved, without regard to the limitations of state law. The rights are vested as of the reservation date, whether or not the water is actually put to use, and are superior to the rights of those who commence the use of water after the reservation date. Depending upon the purposes of the reservation, federally reserved rights may include water for consumptive uses, such as domestic and irrigation, as well as nonconsumptive uses, such as instream flow.

Research on the development and use of federal and non-perfected water rights located within or outside Theodore Roosevelt National Park was completed in 1964. At that time, inspection of records at the State Engineer's Office in Bismarck, N.D., and the courthouse records in Billings and McKenzie counties revealed no record of any wells other than the eight water rights filed by the National Park Service in 1964. These eight filings covered the public water sources in use in the park and have been kept current through the annual use report to the state. The only permit added since then is for an additional well for public use at Cottonwood Campground. A list of existing and abandoned wells is included in the 1964 report, but there is no record of application for water rights except for those wells developed for public use. None of the wells has been adjudicated nor have water rights for any surface waters been secured.

Given the elapsed time and the varied and multiple land uses surrounding the park, it is not known to what extent the park's water resources may be protected, in some measure, by both state appropriative and federally reserved water rights. A water rights evaluation is needed that will identify state appropriative rights presently certified for use on, or diversion from, park lands; determine water rights or uses not on record; and, identify alternatives to protect or acquire rights, as applicable.

Description of Recommended Project or Activity

A project will be conducted with the assistance of the Water Resources Division to:

1. Determine the status of water rights in the park through an inventory of existing water sources, developments, uses and needs.

2. Examine the dependence of park purposes and resources on water.

3. Explore all potential means for acquiring or developing water to meet the management needs of Theodore Roosevelt National Park, and address appropriate uses. Options may include some combination of state appropriative and federally reserved water rights.

4. Files and records held by other government agencies will be examined, field surveys initiated (if necessary), and information and opinions from the Office of the Solicitor, among others, will be requested.

BUDGET AND FTEs:					
FUNDED					
	Source	Activity	Fund Type	Budget($1000s)	FTEs
Year 1	PKBASE-NR	MON	One-time	1.00	0.30
			Total:	**1.00**	**0.30**
	Source	Activity	Fund Type	Budget($1000s)	FTEs
Year 1	WATER	MON	One-time	10.00	0.00
			Total:	**10.00**	**0.00**

(Optional) Alternative Actions/Solutions and Impacts
(No information provided)

Compliance codes :EXCL (CATEGORICAL EXCLUSION)

Explanation: 516 DM2 1, 1.6, 516 DM6 7.4 B(1O)

Project Statement
THRO-N-200.005

Last Update:	09/15/98	Priority: 0000
Initial Proposal:	01/15/98	Page Number: 0001

Title: PREPARE HAZARDOUS SUBSTANCE AND SPILL CONTINGENCY PLAN
Funding Status: Funded: 0.00 Unfunded: 13.00

Servicewide Issues: Nil (WATER QUALITY)

N16 (NEAR-PARK DEVELOPMENT)

Cultural Resource Type:
N-RMAP Program codes: QOO (Water Resources Management)
QOl (Water Resources Management)

10-238 Package Number:

Problem Statement

The major surface water resource in Theodore Roosevelt National Park is the Little Missouri River. The Little Missouri River extends for 225 miles from its headwaters in northeastern Wyoming and terminates upon entering the Gamson Reservoir. The park is located midway within the watershed. The river bisects the park's designated wilderness, and flows through two of the park's three units:
nine miles of the South Unit and 14 miles of the North Unit. It forms approximately one mile of the eastern boundary of the Elkhorn Unit. The river is wild, free flowing, and is designated as a State Scenic River. It is also eligible for National Wild and Scenic River designation. The North Dakota State Department of Health and Consolidated Laboratories, Division of Water Quality, has classified the Little Missouri River as Class 2 (Aquatic Fish and Wildlife, Warm Water Fisheries, and Recreation). The creeks within tributary watersheds of the park are mostly intermittent.

Theodore Roosevelt National Park lies in the heart of the Williston Basin, a very successful oil and gas development area. Numerous oil fields surround all units of the park containing active, shut-in, plugged, and saltwater injection wells; petroleum, gas, and saltwater pipelines; active and buried reserve pits; and, storage tanks. Pipelines cross the Little Missouri River, and wells and pipelines are located in river and tributary floodplains upstream from the park. Such developments, and their associated infrastructures, create a potential for oil and chemical contamination, as well as spills of hazardous substances. Presently 1,500 wells surround the park and 630 new wells are forecast in the next *5* to 10 years. Development in the watershed has the potential to seriously impair water quality, reduce surface and ground water quantity, and negatively affect biological resources in the park. Concomitantly, the risk of hazardous substance/oil spills increases substantially.

Similarly, transportation corridors, such as Interstate 94, which essentially forms the southern border of the South Unit and the railroad south of Interstate 94, cross park waters, including the

Little Missouri Rivet Given these potential pollution pathways, spills or runoff of hazardous substances could directly affect park water resources.

Ongoing agricultural practices adjacent to park units are also a potential threat **to** park water resources. Herbicides, pesticides, and fertilizers are commonly used and are possible sources of spills that would impact both surface and ground water. Herbicide use by the park (primarily picloram for leafy spurge control) could also be a source of spills within the park. Together, energy and agricultural activities and the potential for hazardous substance spills pose a serious and imminent threat to surface and ground water resource integrity in the park.

An additional water resource concern within the park is associated with public drinking water supply and wildlife watering systems. Petroleum or salt water contamination of ground water, which feeds springs and wells is seen as possibly the highest risk to park water resources. Inspections of production facilities, well bores, and salt water injection sites is an important aspect of protection for the park.

The potential for hazardous substance spills to occur within the Little Missouri River watershed and park boundaries is serious enough to warrant a contingency plan for a wide array **of** spill types. In the case of a major spill, response would be coordinated by the Federal Regional Response Team. However, Theodore Roosevelt National Park needs to develop a hazardous spill contingency plan outlining standard operational procedures from the time a spill is discovered to when appropriate spill response authorities arrive on the scene. In addition, the hazardous spill contingency plan should identify equipment, response activities, and training requirements to address the small spills (fuel, sewage, etc.) that may occasionally occur.

Preparation of a hazardous spill contingency plan would place the park in compliance with National Park Service requirements for incidents involving hazardous materials and with the Oil Pollution Act of 1990.

Description of Recommended Project or Activity

The development of a hazardous substance/oil spill contingency plan will begin with a review of all spills that have affected Theodore Roosevelt National Park in the past, and include an evaluation of actions taken in response to these spills. In addition, all applicable regional or local hazardous materials spill contingency plans, and standard operating procedures for spill response will be acquired and reviewed.

Park staff will prepare the contingency plan with special emphasis on petroleum products and agricultural chemicals. Park response to a spill will be detailed in the plan, and standard operating procedures will be developed for small spills that can be handled locally. The plan will also identify notification and response procedures for larger spills which require immediate additional assistance. Information relating to necessary spill response equipment, and personnel training needs for potential spill response will be provided. The park will identify inventory needs in order to delineate high value and particularly spill-sensitive natural resources. In the event of a major spill, a mechanism will be developed to provide resource-specific information and advice to the Department of Interior Regional Response Team representative.

This plan will be developed in conjunction with the Hazardous Materials Office of the National Park Service, and where practical, in collaboration with municipalities and other land management agencies in the region. Preparation of an oil spill contingency plan will require coordination with the U.S. Environmental Protection Agency, U.S. Coast Guard, U.S. Forest Service, North Dakota Department of Fish and Wildlife, North Dakota Department of Health, and probably several other entities that will be identified during the planning process.

Once completed, the park will conduct safety meetings and preparedness drills annually as specified in the plan. Costs identified for this project primarily reflect staff time and travel to develop the plan, including coordination efforts with local and regional agencies and businesses. Most of these costs and FTEs are included in the first year of the budget. Costs in years two through four are much less than the first-year costs, and largely support safety meetings, preparedness drills, and efforts needed to revise the plan as regulations and activities change.

BUDGET AND FTEs					
			FUNDED		
	Source	Activity	Fund Type	Budget ($1000)	FTEs
Total:	**0.00**	**0.00**			
			UNFUNDED		
Year 1	**PKBASE**			**10.00**	**0.25**
Year 2	**PKBASE**			**1.00**	**0.10**
Year 3	**PKBASE**			**1.00**	**0.10**
Year 4	**PKBASE**			**1.00**	**0.10**
Total:	**13.00**	**0.55**			

(Optional) Alternative Actions/Solutions and Impacts

Compliance Codes: EXCL (CATEGORICAL EXCLUSION)
Explanation: 516 DM2 App 7.4 B(11)

Project Statement
THRO-N-200.006

Last Update: 09/15/98 Priority: 0000

Initial Proposal: 01/15/98 Page Number: 0001

Title: ASSESSMENT OF AQUATIC BIOLOGICAL INTEGRITY
Funding Status: Funded: 0.00 Unfunded: 40.00

Servicewide Issues: Nil (WATER QUALITY)
N16 (NEAR-PARK DEVELOPMENT)

Cultural Resource Type:
N-RMAP Program Codes: HOO
EOO

10-23 8 Package Number:

Problem Statement

Historically, water resource managers either ignored biological systems or implemented policy with only a narrow concept of biological conditions and their importance to human society. Reductionist viewpoints dominated water management. Legal and regulatory programs avoided most biological issues and contexts, and precise biological goals were not well developed or defined. Field methods to measure biological condition were not established, and links between field measurements and enforceable goals were weak. In addition, approaches to measuring biological condition were not cost effective (Karr 1991).

The phrase "biological integrity" was first used in 1972 to establish the goal of the Clean Water Act: "to restore and maintain the chemical, physical, and biological integrity of the Nation's waters." This mandate clearly created a legal foundation for protecting aquatic biota. Unfortunately, the vision of biological integrity was not reflected in the act's implementing regulations. These regulations were aimed at controlling or reducing release of chemical contaminants, thereby protecting human health. The integrity of biological communities was ignored (Karr 1991). As a result, aquatic organisms and aquatic environments have declined precipitously in recent decades. The present water resources crisis extends far beyond pollutant-caused degradation of water quality. Loss of species, homogenized biological assemblages, and lost fisheries are other consequences of water resource deterioration. Widespread recognition of the continued degradation of water resources has stimulated numerous efforts to improve the ability to track the condition of aquatic ecosystems (Davis and Simon 1995). Comprehensive, multimetric indexes (Barbour et al. 1995) were first developed in the midwestern United States for use with fishes (Karr 1981; Fausch et al. 1984; Karr Ct al. 1986) and modified for use with invertebrates (Plafkin et al. 1989; Kerans and Karr 1994; Deshon 1995; Fore et al. 1996). The conceptual underpinnings of the multimetric approach have now been applied to a variety of geographic locations (Lyons et al. 1995) and aquatic environments (Davis and Simon 1995), including large rivers, lakes, estuaries, wetlands, riparian corridors, and reservoirs.

The fundamental ecological principle of these multimetric indices is that various trophic levels in aquatic systems require a broad diversity of intact ecological functions and processes to survive, grow, and reproduce. These indices incorporate many attributes of aquatic communities that cover a range of ecological levels, and reflect the multiple stresses found in modified ecosystems. The original multimetric index, the Index of Biotic Integrity (Karr et al. 1986), summarized stream fish collection data into 12 ecological characteristics from three categories: species richness and composition, trophic composition, and fish abundance and condition. The 12 metrics reflect insight from several perspectives: individual, population, community, ecosystem, and zoogeographic. Each metric is scored as poor, good, or excellent relative to an ‘expected community’ derived from a natural undisturbed ecosystem of similar size, which exhibits characteristics from the same ecoregion. The strength of these multimetric indices is that many factors which affect biotic integrity can be seen or measured. Ultimately, these factors include food (energy) source, water quality, habitat structure, water flow, and biotic interactions.

Only three states used multimetric biological approaches in 1989. Today, more comprehensive approaches have been developed and are being adopted by state and federal agencies. Forty-seven states now use multimetric assessments of biological condition, and six states are developing biological assessment approaches (U.S. Environmental Protection Agency 1996a). Efforts are finally being made to monitor the biological integrity of water resources as mandated by the Clean Water Act 25 years ago (Karr 1991; Davis and Simon 1995; U.S. Environmental Protection Agency 1996a,b).

Among the most effective monitoring programs are those that make use of a variety of chemical, toxicological, and biological assessment techniques, which improve the capability to detect a wide range of water quality problems. Ohio Environmental Protection Agency has found that the use of a combination of chemical/physical analyses, bioassays, and biological field techniques can identify problems that were previously unknown or the severity had been underestimated. At six percent of 431 sites assessed by Ohio Environmental Protection Agency (Ohio Environmental Protection Agency 1988), chemical analyses detected impairment missed by biological surveys, and at 36 percent of the sites, biological surveys detected impairment that chemical data missed.

In addition, multimetric indices facilitate communication of complex ecological data. Some scientists have expressed concern about indices that summarize too much information into a single number (Elliot 1994). The simple additive scaling and equal weighting of metrics in most multimetric indices allow users to easily examine its component parts and to identify how each metric contributes to the overall score. Also, use of a multimetric index does not preclude examining and interpreting species composition data, if this is considered necessary, desirable, or expedient.

Description of Recommended Project or Activity

The North Dakota Department of Health began biological monitoring in 1993, limiting its effort to the Red River of the North basin. Funded by a grant from the U.S. Environmental Protection Agency, the department developed a fish-based multimetric index with the help of a number of state and federal agencies. In 1995, the department added macroinvertebrate community sampling as a compliment to the fish sampling. This new sampling program was piloted in the Red River and had the following objectives: to develop field sampling procedures for stream macromvertebrate communities; to develop laboratory procedures for macroinvertebrate identification and enumeration; and, to develop potential metrics for macroinvertebrates and evaluate their usefulness in developing biological criteria along with the fish-based index as a stream water quality protection and assessment tool.

The North Dakota Department of Health's multimetric index for stream macromvertebrate communities is based upon the U.S. Environmental Protection Agency's Rapid Bioassessment Protocols (Pflakin et al. 1989). These protocols consist of three basic components: water quality/physical characteristics, habitat assessment, and a biosurvey.

The water quality/physical characteristics component measures aspects of the riparian zone/instream features, sediment/substrate, and water quality. The habitat assessment is a composite index that rates (excellent to poor) such habitat variables as bottom substrate, embeddedness, flow, channel alteration, pool/riffle or run/bend ratios, bank stability, and streamside cover. The biosurvey assesses macroinvertebrates by determining such metrics as taxa richness, EPT (i.e., Ephemeroptera, Plecoptera, Trichoptera) index, community loss index, ratio of scrapers to filter feeders, ratio of shredders to the total number of individuals, percent contribution of dominant family, and family biotic index.

In an effort to foster partnering and to reduce duplicative efforts, Theodore Roosevelt National Park will contact the North Dakota Department of Health about the possibilities of a pilot study that would test and refine the Red River macromvertebrate multimetric index for western North Dakota using the aquatic environment of the park. Depending upon state involvement, the park could then either conduct its own biological assessment program (with appropriate training), conduct the sampling and contract to the state the identification and analysis phases, or just contract to the state all phases (sampling, identification, and analysis). The ultimate goal would be to establish several, permanent, park-based sampling stations as part of North Dakota's monitoring and assessment program. To this end, the park would be able to assess biotic integrity of its streams on a regular basis with minimal personnel and monetary investments.

The use of North Dakota's approach is the most cost-effective because the state has been employing this method since 1995, and the trial and error phase is complete. While there may be other candidate approaches, these would have to be tested for applicability to northwestern Great Plains stream, and may have to be modified. This would require greater upfront costs and time commitments prior to any use of a new approach.

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BUDGET AND FTEs:				
Funded				
Source	Activity	Fund Type	Budget($1000)	FTES
		Total:	**0.00**	**0.00**

UNFUNDED				
Source	Activity	Fund Type	Budget ($l000s)	FTEs
Year 1:	MON	One-time	20.00	0.00
Year 2:	MON	One-time	20.00	0.00
Total:	**40.00**	**0.00**		

(Optional) Alternative Actions/Solutions and Impacts
(No information provided)

Compliance codes : EXCL (CATEGORICAL EXCLUSION)
Explanation: 516 DM2 APP. 2, 1.6

Project Statement
THRO-N-200.007

Last Update:	09/15/98	Priority:	0000
Initial Proposal:	01/15/98	Page Number:	0001

Title: HERBICIDE ASSESSMENT
Funding Status: Funded: 0.00 Unfunded: 60.0

Servicewide Issues: Ni 1 (WATER QUALITY)

N20 (BASELINE DATA)

Cultural Resource Type:
N-RMAP Program Codes: QOO (Water Resources Management)
QOl (Water Resources Management)

10-238 Package Number:

Problem Statement

Leafy spurge *(Euphorbia esula)* is one of the most aggressive and troublesome plants in the western United States. Of the approximately *2.5* million acres infested with leafy spurge, more than half are in North Dakota and Montana. Leafy spurge occupies a broad ecological range of habitats, from xeric to subhumid, and from subtropical to subartic. It will tolerate flooding over periods of at least four to five months, provided the shoots can grow above the water surface. Although leafy spurge frequently becomes established in moist places, it also is well adapted to dry, upland sites and shallow, rocky soils. Leafy spurge grows in nearly all soil types, but appears to favor coarse textured soils.

Much of the land area adjacent to Theodore Roosevelt National Park supports agricultural activity, which, as currently practiced, necessitates exotic weed control to maintain viability. Leafy spurge is a serious problem within and outside Theodore Roosevelt National Park. Its invasion is disrupting native plant communities and threatening the survival of several rare plant communities. In addition, leafy spurge has no forage value to the large native ungulates in the park, and its presence is therefore reducing the carrying capacity of the area (National Park Service 1994).

Leafy spurge was brought into North Dakota by Eastern Europeans during the homesteading period. Locally, leafy spurge originated west of the park in Golden Valley County along Knutson Creek during the 1930's. Leafy spurge was first reported in the park in the late 1960s. In 1970, park managers estimated that there were 32 acres of 1eaf~' spurge infestation, divided into 103 separate patches ranging from a few square meters to three acres. In 1971, the herbicide Tordon was placed on the restricted use list and the National Park Service did not authorize its use. As a result of fiscal cutbacks, the park eliminated leafy spurge control from the 1971 program. Leafy spurge control began in the park in 1975 and currently consists of herbicide applications and a biological control program in cooperation with the Animal and Plant Health Inspection Service, Agricultural Research Service, North Dakota Department *of* Agriculture, and North Dakota State University. Between

1975 and 1983, the infestation was estimated at 400 acres. In 1986, 700 acres was the conservative estimate of leafy spurge infestation in the park.

The success of chemical control prior to 1992 was limited because of limited resources, difficult access in the backcountry, and the existence of a designated wilderness. The biological control program is currently limited to a small scale, and the ability to use this **approach** on a large scale is a hope for the future. The park has recently used a micro-foil boom helicopter for spraying larger acreages in areas of difficult access. This approach to chemical spraying is highly specialized and uses a boom capable of precise targeting of chemicals with virtually no chemical drift.

Since leafy spurge appears to grow primarily in drainage channels and creak and river bottoms (Anderson et al. 1994), it is critical that careful planning occur before eradication treatment begins. An integrated pest management approach, which includes the use of herbicides, has been instituted by the park (National Park Service 1994). Herbicides being used include picloram, glyphosate, 2,4-D, and fosamine ammonium, **or** combinations thereof.

Most concern about herbicide application has focused on its aerial application, as it is very difficult to prevent some spray from being applied in or near the stream channels. In addition to the contamination problem posed by overspray and drift, herbicides can be transported from the point of application to the aquatic ecosystem by leaching, volatilization, and erosion. In most cases, the risk of contamination from these three transport processes is lower than risk of contamination from direct overspraying and drift (U.S. Environmental Protection Agency 1977 cited in MacDonald et al. 1991).

The susceptibility of a chemical to leaching depends on its solubility in water and its tendency to adhere to soil particles. Another pathway for these chemicals to reach the aquatic ecosystem is by absorption onto soil particles and subsequent erosion. The dependence of these transport mechanisms on the movement of water means that the potential for contaminating streams is closely tied to the amount of precipitation, runoff, and erosion following application. High runoff events shortly after application generally pose the greatest risk for loss from the terrestrial environment to the aquatic ecosystem. The tendency to use less persistent herbicides and the relatively low levels of pesticide application suggest that the transport from the terrestrial to the aquatic ecosystem is rarely a problem except for a few chemicals such as picloram (MacDonald et al. 1991).

The possibility of sublethal effects on aquatic organisms cannot be excluded, but intermittent application, short duration of exposure, and relatively low concentrations of herbicides, all suggest that these effects generally are small or *insignificant.* A detailed study of the effects of glyphosate on a stream in coastal British Columbia, for example, confirmed short-term avoidance and stress by Coho salmon and two species of invertebrates in an oversprayed tributary; long-term effects were deemed negligible (Reynolds et al. 1989).

The following plan was implemented in 1994 by the park (National Park Service) for chemical application of herbicide to control leafy spurge. Plan recommendations are restricted to the South Unit because infestation and control have been focused on this unit. The North Unit is relatively free of leafy spurge.

1. The smaller infestations in the south Paddock Creek area should be controlled with high rates of picloram (>1 lb/A) to prevent the now isolated infestations from joining another large area such as in the Petrified Forest. The maximum use rate of picloram is 2 lb/A and should be used as much as possible on the small (<1 A) infestations. There are two reasons for the high rate: 1) to gain 90% or more control immediately, thus preventing spread; and, 2) to avoid having to pay for helicopter time over the same small areas every year.

   The maximum labeled use rate may not be applicable in all areas with small patches. The depth to ground water and potential for runoff and thus movement into surface water, must be considered. However, the dilution factor is large when spraying small patches in a large area so the same potential for contamination is small compared to spraying high rates over the entire area.

2. On the larger areas of the South Paddock Creek area, a 3 to *5-year* chemical control plan should begin. The recommended herbicides include picloram plus 2,4-D at *0.5* + 1 lb/A in areas where streams or ground water table is not a concern. Expect about *85* percent control after three years. A second option in glyphosate plus 2,4-D at 0.4 + 0.6 lb/A applied in late June or early July. Control will be about 70 percent the next year. The follow-up treatment must be picloram plus 2,4-D at 0.25 + 1 lb/A, because glyphosate applied in two successive years will damage grasses. It is critical that the application of glyphosate plus 2,4-D be properly calibrated to prevent injury to grasses. An alternative treatment approach would be to alternate between glyphosate plus 2,4-D and picloram plus 2,4-D, with glyphosate plus 2,4-D applied in years one and three and piclorain plus 2,4-D applied in years two and four.

   Along the stream itself, Rodeo plus 2,4-D (using a 2,4-D formulation that is labeled for water) should be applied in mid to late July to begin reducing the infestation. Expect about 70 percent control the following year with this treatment. If erosion or bare ground is a concern, then use 2,4-D (labeled for use in water) at 1 to 2 lb/A annually. The 2,4-D treatment will not reduce the original infestation but will keep it in check.

   In small areas, fosaniine (Krenite) at 6 to 8 lb/A could be used up to the waters edge, but this is an expensive treatment. Expect about 80 percent control with this treatment one year after application.

3. Moving north into the Little Missouri River and Knutson Creek area, the infestations are much more dense and well established. These areas (excluding riparian areas and woody draws) will require annual applications of picloram plus 2,4-D for at least five years before achieving *85* percent or more control. If monies are available, this treatment should begin in 1994. However, if chemical treatments cannot begin in 1994, then this area would be best served by a non-chemical approach such as grazing or biocontrol agents.

   At minimum, the annual application should treat the edges of the infestation. This will limit the spread of leafy spurge into non-infested land.

The following table (Table 1) presents characteristics and known water quality criteria for the herbicides currently in use to control leafy spurge in the park. Glyphosate dissipates rapidly from the water column as a result of adsorption and possibly biodegradation. Due to its ionic state in water, it does not readily volatilize from water or soil. Glyphosate is so strongly attracted to soil that little is expected to leach from an applied area. What would leach to ground or surface waters is not toxic to fish or aquatic invertebrates.

Table 1. Characteristics and water quality standards of herbicides used in Theodore Roosevelt National Park. The water quality criteria for aquatic life are **from Canada; no** similar criteria have been developed in the U.S.

Herbicide	**U.S. Drinking Water Standard (MCL in mg/i)**	**Persistence in Soil (Half-life in days)**	**Persistence in Water (Half-life in days)**	**Water Quality Criteria for Aquatic Life (ugh)**
Glyphosate	0.7	30 to 100	a few days	*65*
Picloram	*0.5*	>100	2 to >40	29~
2,4-D	0.07	<30	10 to >50	4
Fosarnine Ammonium	None	7 to 10	Unknown	None

Interim guideline in Canada.

Source: U.S. Environmental Protection Agency 1998.

Picloram is very persistent in soil and moderately persistent in water; however, once it enters the ground water it is long lived. It is very soluble in water and will not absorb to sediments nor will it evaporate or hydrolyze appreciably. Picloram is moderately toxic to fish and slightly toxic to aquatic invertebrates.

2,4-D shows low persistence in soil and is the most persistent in water. Leaching to ground water will likely be a significant process in coarse-gramed sandy soils with low organic content or very basic soils. Percolating water appears to be the principal means of movement for this chemical. Some formulations of 2,4-D are highly toxic to fish while others are less so.

Fosamine ammonium (Krenite) is the least persistent in soil; however, its persistence in water is unknown. It is rapidly decomposed by soil microorganisms. Though quite soluble in water, fosamine ammonium does not show much leaching with soil depth. Fosamme amnionium has low aquatic toxicity to fish and aquatic invertebrates. The 96-hour LC5O for the fathead minnow was greater than 1,000 mg/i, and the 48-hour LC5O for *Daphnia magma* was 1,524 mg/i.

The park conducted a limited water quality monitoring program for picloram and 2,4-D concentrations from 1993 to 1995. Sample sites included Paddock Creek (stations 027 and 036), Knutson Creek (stations 042 and 069), and Wannagan Creek (stations 064, 068, 070, and 071). The range in median concentrations for picloram (20 detectable samples) was 0.05 to 9.15 ugh; for 2,4-D (10 detectable samples) the range was 0.25 to 14.8 ugh. None of the concentrations was in excess of U.S. drinking water standards (Table 1). However, two sites on Wannagan Creek (stations 064 and 070) had median concentrations for 2,4-D above the 4 ugh water quality criterion for aquatic life (Table 1).

Baseline water quality information is needed so that Theodore Roosevelt National Park can evaluate whether its efforts to control chemically leafy spurge will be more of an environmental cost than benefit. Furthermore, understanding the areal extent and concentration of herbicides after eradication efforts within park boundaries should allow the park to comprehend the potential for contamination of park water resources from transboundary efforts.

Description of Recommended Project or Activity

1) Given that laboratory costs could be as high as $100/herbicide, a cost-effective monitoring program should be considered. Due to its characteristics, discussed above, glyphosate will not be a tested parameter. Herbicide monitoring will be limited to picloram and 2,4-D, often among the most frequently found herbicides in ground water (Wood 1996) because of their persistence and mobility in water (see characteristics discussed above). Krenite (fosamine ammonium), another potential herbicide considered for use in the park, has characteristics similar to those for glyphosate.

2) The ground water **flow** gradient of the Tongue River and Hell Creek-Fox Hills aquifers is toward the Little Missouri River, and in a more general sense, from south to north. The Little Missouri River, because of its topographically low position, acts as a discharge zone for the aquifers lower than the river valley alluvium. The completion zones of flowing wells in the area are overlain by confming layers of silt and clay. Due to the upward pressure gradient (artesian) and the presence of conforming layers, the chances of detectable quantities of herbicides reaching the well completion zones are low. Therefore, a robust monitoring scheme for picloram and 2,4-D in drinking water supplies is not recommended. Instead, the Peaceful Valley well, because it is completed at a relatively shallow depth of 424 feet, should be sampled as an indicator well for possible drinking water supply contamination. Water from this well will be sampled two to three times per year after each herbicide application -- once each in summer and *fall,* and a possible third sampling in the spring following herbicide application.

   Some springs ringing the sprayed plateaus (Big Plateau and Petrified Forest Plateau) may comprise outlets of recharge waters from the plateaus themselves at the interface of sand or coal deposits over shale and clay layers (Schuh and Wanek 1992). Water may flow in fractures from the upper plateau and discharge at such sites along the sides of the plateaus. These springs, all on the west side of the Little Missouri, including the Lone Tree, Sheep Pasture, Big Plateau, Tomamichael, and Eckblom, would be the best indicators of possible water contamination coming from the plateaus. The North Dakota State Water Commission should be consulted to determine possible east side springs to sample.

   These springs will also be sampled two to three times per year -- once each in the summer and fall, and a possible third sampling in the spring following herbicide application. Given that *transit* times to springs are unknown and unpredictable, these three samplings should provide a good opportunity to determine if herbicide contamination of springs has occurred.

   There would be little benefit in trying to drill monitoring wells to anticipate contamination of the springs because the location of water-bearing formations related to the springs would be almost entirely hit or miss.

3) The first objective of surface water monitoring -- to document the amount of unwanted chemicals entering the aquatic system -- is probably rarely achieved because of the temporal variation in herbicide concentrations (MacDonald et al. 1991). A few grab samples may or may not capture the peak concentration. In the absence of information on the shape of the concentration curve over time, the reliability of grab samples is very low, and minor changes in sampling location or time could dramatically affect the observed concentration. Therefore, the critical aspect in monitoring herbicide applications is the selection of monitoring locations and the timing of the water samples.

   Suggested surface water sampling sites include: Paddock Creek at its junction with the Scenic Loop Road; the unnamed tributary to Little Wannagan Creek at its junction with the Petrified Forest Loop Trail, just inside the park boundary; Knutson Creek at its junction with the Lone Tree Loop Trail; the unnamed tributary to the Little Missouri River immediately north of Big Plateau with sampling to occur approximately one-quarter mile upstream from its confluence with Little Missouri River; and, the unnamed western tributaries of the Little Missouri River that are just north and south of the VA well location, also to be sampled approximately one-quarter mile upstream from their confluences.

   The usual procedure with reference to timing of water samples is to take one sample immediately prior to application and a series of samples at various times after herbicide application (MacDonald et al. 1991). However, due to the arid climate, all surface waters with potential for herbicide contamination are either ephemeral or intermittent. Therefore, water samples for this study must be storm-event related. Each of the above surface water stations will be sampled after the *first* large storm following the herbicide application. If picloram is detected, then second water samples will be taken during the next large storm event. If no detections occur in the first such event, then surface water sampling at that station will be discontinued until after the next herbicide application.

   If there are no sufficient storms to cause runoff that can be sampled, then there is negligible risk of surface water contamination. However, under such conditions, herbicide breakdown might be unusually slow so that a sampling the following year would be appropriate. If there is no opportunity to sample in the year of herbicide spraying, samples should be considered for the following year.

   At each surface water site, six water samples will be taken -- three during the ascending limb of the runoff flow curve and three during the descending limb. To minimize costs of analysis, a portion of each sample will be combined into a composite sample. The composite sample will be analyzed, and the remaining portions of the individual samples will be tested only if picloram is detected in the composite sample.

4) The North Dakota State Water Commission and North Dakota Department of Health will be consulted with regard to standard operating procedures and QAJQC for water samples as well as for suggestions in sampling from an intermittent and shallow source.

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BUDGET AND FTES

FUNDED					
	Source	Activity	Fund Type	Budget ($l000s)	FTEs
			Total:	**0.00**	**0.00**

UNFUNDED				
Source	Activity	Fund Type	Budget ($l000s)	FTEs
Year 1:	MON	One-time	15.00	0.10
Year 2:	MON	One-time	15.00	0.10
Year 3:	MON	One-time	15.00	0.10
Year 4:	MON	One-time	15.00	0.10
			Total: 60.00	**0.40**

(Optional) Alternative Actions/Solutions and Impacts (No information provided)

Compliance codes EXCL (CATEGORICAL EXCLUSION)

Explanation: *516* DM2 APP. 2, 1.6

Project Statement
THRO-N-200.008

Last Update:	09/15/98	Priority: 0000
Initial Proposal:	1998	Page Number: 0001

Title: STREAM, SEEP, AND SPRiNG EXCLOSURE PROJECT
Funding Status: Funded: 0.00 Unfunded: 21.00

Servicewide Issues: Nil (WATER QUAL-EXT)
N12 (WATER FLOW)

Cultural Resource Type: **QOO** (Water Resources Management)

N-RMAP Program Codes: QOl (Water Resources Management)

10-238 Package Number:

Problem Statement

Forty-two percent of the non-park land in the Little Missouri River watershed is used as pastureland and rangeland. Park staff have cited concerns about problems related to overgrazing in areas outside the park boundaries. Much of the park land *is* also affected by grazing of bison on seeps, springs, and some riparian areas. The physical effects of large numbers of bison using these areas for their source of water can have dramatically negative impacts on these resources in a relatively short period of time. Grazing has potentially detrimental effects on stream banks, water column, aquatic life, stream channels, and vegetation. Park staff have already observed significant damage of seep and spring areas resulting from heavy use by bison.

Grazing also has the potential to cause detrimental effects on beneficial uses of water. Nonpoint source effects fall into three categories: 1) a change in the chemical, physical, and bacteriological characteristics of water; 2) modification of habitat by changes to the stream channel and vegetation; and, 3) changes to stream flow patterns.

Wetlands and riparian areas, including seeps and springs, are some of the most productive and significant natural resources at Theodore Roosevelt National Park. Seeps include those springs whose discharge is diffuse and generally immeasurable as there is not a defined channel or opening where the discharge is concentrated. Important for the vegetation they support, and in turn for the wildlife supported by that vegetation, seeps can also be a source of emergency water supply to wildlife or park visitors by collecting enough water in troughs or depressions to be useful.

Springs are a special class of seep, characterized by well-defined flow paths which lend them to capture and development. Springs represent the most important source of water for wildlife in the backcountry;

however, as such, springs become concentration areas where herds of ungulates will gather, leading to degradation of the resource.

Seeps and springs can provide sources of water in areas far from the Little Missouri River. They may also support unique flora and fauna. Damage to seeps and springs could jeopardize wildlife populations and other fauna and flora.

There are 16 known springs in the park, four in the North Unit and 12 in the South Unit (Table 3). There are innumerable other springs and seeps in the park which have not been inventoried. Ten of these known springs have been 'developed.' In the early 1960s, a number of 300- to 500-gallon concrete containers called dish tanks were installed at various spring locations in the park. These tanks are situated at ground level and are either spring or well fed. Dish tanks were placed as part of the wildlife management program, to provide water resources, but more importantly to disperse range use by the large ungulates.

Closures of riparian-wetland and aquatic habitats to livestock grazing has been used in many locations throughout the West to qualitatively and quantitatively demonstrate the effects of eliminating or reducing grazing (Duff 1977; Kauffman et al. 1983; Rinne 1988; Tiedemann et al. 1987). Changes, even in small plots, in species composition, plant growth, distribution of vegetation, and structure and function of aquatic habitats following closures can be dramatic. Documentation of such changes could be used to estimate the park's natural capacity under less disturbed conditions. This approach has some limitations because land-use practices in a watershed far removed from an exclosure can have effects on habitats within an exclosure (Duff 1977).

Description of Recommended Project or Activity

Since the main damage to springs and seeps comes from the bison within the park, one of the approaches to managing this problem is the construction of an exclosure. Temporary fencing, or an exclosure, around a riparian system which is not functioning properly, allows the system to restore itself and may be one of the quickest methods of rehabilitation to an area (Platts and Wagstaff 1984). In Theodore Roosevelt National Park, an exclosure would prevent access of bison and other large ungulates to a damaged spring or seep area, allowing it time to recover.

1) The park would conduct a literature review for information on grazing exciosures that were established either in the Northern Great Plains or elsewhere. Since there are currently no standard operating procedures for constructing bison exciosures (Rapid City, SD), National Bison Range staff (Moise, MN), pers. comm. 1998~, a U.S. Bureau of Land Management technical bulletin addressing livestock exciosures is suggested as a starting point (U.S. Bureau of Land Management 1997). The concern with any standard livestock exclosure is that bison have superior size, strength, and determination in comparison to typical livestock. Also, electric fencing has no effect on bison. Thus, exclosure structures for bison will have to be significantly reinforced to withstand the pressure, and should not be electrified. Before construction, Theodore Roosevelt National Park *staff* should consult with experts from the National Bison Range in Moise, Mont. (Dave Wiseman, pers. comm. 1998).

   After enclosures are in place, determination of the time needed to rehabilitate a degraded riparian area is a matter of debate (Skovlin 1984; Platts and Raleigh 1984). Any determination must consider factors as current physical and hydrologic conditions; existing, potential, and desired flora communities; and, topography, hydrology, and climate. At Theodore Roosevelt National Park, the

1eafy spurge invasion complicates solutions. Leafs' spurge out-competes native vegetation, and bison will not graze on leafy spurge, making a damaged area even more difficult to manage and rehabilitate. In the best of circumstances, reparation is rarely immediate, often taking several years for full recovery (Platts and Raleigh 1984; Hubert et al. 1985).

2) Select one spring/seep in a park watershed where grazing would be excluded starting about three years into the future. This spring/seep is called the treatment. A comparable spring/seep in the same watershed should be selected; grazing would continue in accordance with existing management strategies. This spring/seep is called the control. The determination of which spring/seep would be the treatment and which would be the control would be random. At least one additional pair of grazed and ungrazed spring/seeps would be selected in another watershed within the park as a replicate. The use of paired replicates enhances the ability to use hypothesis testing to evaluate differences between treatments regardless of the natural variation among the different spring/seeps.

3) The paired treatment and control spring/seeps would be monitored for 3 years prior to fencing of the treatment sections to exclude ungulates. Although treatment and control sites would be selected to minimize differences between them, this pre-project calibration period would provide quantifiable data to describe the inevitable differences. Ungulates would be excluded from each treatment spring/seep at the end of the calibration period, and monitoring of the condition of the treatment and control sites would commence one year after the ungulates were excluded. The park would continue the monitoring program after the enclosures were in place for a minimum of 10 years.

4) Physical, chemical, and biological characteristics of the springs/seeps would be monitored using a combination of field sampling, photo points, and aerial photos. Platts et al. (1983), Platts et al. (1987), and Myers (1989) would be the sources for methodology. Potential measures include use of: a) channel cross sections placed perpendicular to spring flow to evaluate use of vegetation by grazing animals; b) stability ratings to assess vegetation overhang and streanibank condition; c) a modified point-frame technique to evaluate streambank surface cover; d) spherical densiometer to evaluation canopy closure; e) distribution of contrasting colors or mottles in soils as indicators of past riparian conditions; and, f) changes in streambank stability and form using a modification of the sag tape procedure. Aquatic flora and *fauna*, in this case diatoms and aquatic macroinvertebrates, would be evaluated for changes in species richness.

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Budget and FTEs

FUNDED				
Source	Activity	Fund Type	Budget ($1,000s)	FTEs
	Total:		**0.00**	**0.00**
UNFUNDED				
Year 1:	MON	One-time	15.00	0.00
Year 2:	MON	One-time	20.00	0.00
		Total:	**35.00**	**0.00**

(Optional) Alternative Actions/Solutions and Impacts (No information provided) Compliance codes: EXCL (CATEGORICAL EXCLUSION) Explanation: 516 DM2 APP. 2,1.6

Project Statement
THRO-N-200.009

Last Update:	09/15/98	Priority: 0000	
Initial Proposal:	1998	Page Number: 0001	

Title: MONITOR WATER SOURCES — SPRINGS AND SEEPS (CYCLIC)

Funding Status: Funded: 12.00 Unfunded: 39.50

Servicewide Issues: N20 (BASELINE DATA)

N12 (WATER FLOW)

Cultural Resource Type: QOO (Water Resources Management)

N-RMAP Program Codes: QOl (Water Resources Management

10-23 8 Package Number:

Problem Statement

There are 16 known springs in the park, four in the North Unit and 12 in the South Unit (Table 1). There are innumerable other springs and seeps in the park which have not been inventoried. Ten of these known springs have been ‘developed.’ In the early 1960s a number of 300 to 500-gallon concrete containers called dish tanks were installed at various spring locations in the park. These tanks are situated at ground level and are either spring or well fed. Dish tanks were placed as part of the wildlife management program, to provide water resources, but more importantly to disperse range use by the large ungulates. These developed water systems require constant maintenance. A number of springs and some seepage areas have been severely degraded by ungulate grazing.

Discharge rates for these springs were taken intermittently by park *staff* in the 1980s. In the 1990s flow information is scarce. The ‘best’ available discharge data is from 1988, where all but one spring was measured (Table 1).

Springs and seeps are important water sources in Theodore Roosevelt National Park. Backcountry springs support important riparian and wildlife habitat. Springs represent an overflow from a ground water reservoir, and the rate of springflow thus tied to the rate of recharge to the ground water reservoir as well as the size of the reservoir. Climate-induced variations in the ground water recharge rate produce subsequent variations in the flow rates of the springs fed by the groundwater reservoir. The size of the ground water reservoir, and the length of the flow paths from the point of groundwater recharge and spring discharge, modulate the climatic forcing function. Thus, the smaller the ground water reservoir and the shorter the flow path, the more rapid and dramatic will be the springflows’ response to climatic fluctuations. For important springs, the park should develop information on the response of springs to climatic variation in order to be able to estimate the flow of springs without visiting them. As the first step in this task, the climatic forcing function (precipitation) and the responses of the springs should be monitored over a minimum of one year's time. This monitoring will help determine the amplitude of the springs' variation and the lag-time between rainfall and peak spring discharge. Once this information is available, park personnel can estimate the flow of such springs by analyzing climatic data. Subsequent fluctuations in climate that exceed the range experienced in the initial monitoring period should initiate a visit to each of the springs to extend the range of climatic conditions for which confident estimates of springflow can be made.

Table 1. Springs of Theodore Roosevelt National Park and their discharge rates.

		Discharge (gallons/minute)						
Springs	Park Unit	1992	1990	1988	1986	1985	1983	1982
Achenback	North				40		30	
Stevens	North	13	9	12	15			
Hagen	North	15	30	23	45			
Overlook	North	300		300	300		300	
Ekblom Well	South			103		68	60	
Tomamichael Well	South			5		5	6	6
RoughRider Well	South			64	68	68		78
SE Corner Well	South	17	24	28		37		o
Sheep Creek Well	South			180		152		
Sheep Butte Spring	South	7		10		7	75	15
Mike Auney Well	South			126		42	30	138
Lone Tree Spring	South	13		16	35	35	60	30
Big Plateau Spring	South	15		15	19	19	30	60
Biocourt Spring	South	7		2	6	6	4	12
VA Wells	South	6		10		11	15	
Jones Creek	South			140		146	180	168

Source: Theodore Roosevelt National Park files.

Description of Recommended Project or Activity

1. Identify, and arrange in priority order, all springs (and any seeps) for which the park desires the capability to confidently estimate springflow based on climatic data. These springs and an equal number of smaller springs distributed over the park would provide a good basis for the springflow monitoring program.

2. Visit the springs identified above and evaluate the best method of monitoring the springflow (i.e., weir, flume, etc.) at each site. For many springs and seeps, measurement of all flow will be impractical, but useful data can be acquired by measuring as large a portion of the flow as *is* reasonably practical and estimating the unmeasured portion. Since it is highly related that the unmeasured and measured portions are systematically related, estimates of the unmeasured component made on monthly visits to service the gage recorders can be used to develop estimates of total flow over the range of flows measured during the year of monitoring.

3. Using the prioritized listing, and the type of measuring device required for each spring, align the springs into like groups, with the objective of minimizing the total of each type of measuring device.

4. Acquire and install the measuring devices on the first group of springs arid begin recording data. After six months of record have been acquired, plot the springflow hydrograph for each spring along with the precipitation data from the nearest precipitation station (daily or even weekly total precipitation would be sufficient), and evaluate the response of the springflow to the rainfall. For springs with large ground water reservoirs, and/or distant sources of recharge, the lag time in the response may preclude such evaluation. For such springs, data must be acquired fro a longer period of record, and, for these springs, data collection should continue. Note that as the lag time increases to a month or more, the rainfall data should be plotted as cumulative departure from the monthly, quarterly, **or** annual average values. Revisit this analytical procedure at six month intervals, and cease data collection at each site as soon as the lag time has been determined. When data collection is discontinued at a site, the equipment should be moved springs in the second group, and the cycle started again.

The process would continue for 2 to 4 years depending on the number of long lag-time springs in the total number of springs being monitored.

BUDGET AND FTEs					
			FUNDED		
	Source	Activity	Fund Type	Budget ($l000s)	FTEs
Year 1:		MON	Cyclic	12.00	0.1
			Total:	**12.00**	**0.1**
			UNFUNDED		
		Year 1: RES	One-time	10.00	0.10
		Year 2: RES	One-time	2.50	0.03
		MON	One-time	10.00	0.00
		Year 3: RES	One-time	2.50	0.03
		Year 4: RES	One-time	2.50	0.03
		Total		**39.50**	**0.19**

(Optional) Alternative Actions/Solutions and Impact (No Information provided)

Compliance Codes: EXCL (Categorical Exclusion)Explanation: 516 DM2 1, 1.6,516 DM6 7.4B(1O)